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Essential Foundry Output Not Yet Defined

Some Nonessentials Are Certain to Have Their Pig Iron Supply Curtailed or Cut Off Entirely—Large Steel Casting Awards for Railroad Requirements

ALTHOUGH no definition of essentials and nonessentials as affecting the foundry industry has yet been made, nevertheless casting plants not strictly engaged in production for ordnance, ships, railroads and equipment for plants employed in government work will experience increasing difficulty in obtaining pig iron. Foundries making castings for the agricultural implement trade undoubtedly will receive preferred classification, but their needs probably will not be met until after the shops doing direct and indirect government work have their requirements satisfied. A committee representing the stove trade recently was advised at Washington that their plants practically have been placed on the nonessential list and furnace builders have been similarly classified. Many of these plants, of course, have liberal stocks of pig iron in their yards and with purchases of scrap iron they may be able, in a limited way, to take care of next season's output.

However, conservation in styles and types of furnaces and stoves has been urged, and it has been pointed out that a great saving in pig iron may be effected if an attempt at standardization be made. It has been the practice in the stove and furnace industry to place new styles in various sizes on the market each season, which entailed the production of enormous stocks placed in the hands of jobbers and dealers throughout the country. The elimination of this practice alone will greatly curtail the iron consumption and will effect much needed economies for the stove and furnace manufacturers. Other economies are contemplated. The thousands and thousands of patterns carried in stocks by the stove and furnace repair shops represent years of accumulation of new style and sizes and reflect, in a measure, the extent of this practice. The limitation of styles also has been recommended to the agricultural implement manufacturers and here again a tremendous saving may be effected in the number of repair parts carried in stock by almost every dealer throughout the country. So detailed and numerous have been the responses to the questionnaire sent to the foundry trade by the blast furnace interests in behalf of the subcommittee on the distribution of pig iron, that no attempt has yet been to make a complete compilation. To attempt to estimate, at this time, the percentage of the foundry output engaged on government orders would be merely guesswork and it is doubtful if this will be known before the middle of July. The replies already received reflect the wholehearted co-operation of the foundry industry and it is doubtful if any plants will have their pig iron supply cut off because of their failure to submit the information sought.

The priority of pig iron distribution has not yet been fixed. Of course, the foundries engaged in the production of castings for the army and navy, the building of ships and for the railroads will receive first consideration and the balance will be apportioned among the plants making the lesser essentials and finally, the nonessentials. Stoves, furnaces, art hardware, sashweights, radiators, etc., undoubtedly will be in the latter class. The growing pig iron production

How War Developments Are Affecting the Foundry Industry

Essentials and nonessentials in casting manufacture are being slowly defined.

No attempt has yet been made to compile the data received on the pig iron questionnaire and the percentage of the foundry melt on government work cannot be estimated.

The reduction of styles and sizes of stoves and furnaces has been recommended and an attempt toward the standardization of agricultural implements has been made.

Tests of experimental semisteel and gray iron shells are encouraging and a production of 12,000,000 has been tentatively suggested requiring more than 1,000,000 tons of iron.

Casting contracts for 100,000 freight cars and 1025 locomotives have been awarded totaling more than 500,000 tons.

Further concessions in the specifications for steel castings have been granted by the United States bureau of army ordnance.

holds out a ray of hope to the foundries making the nonessential castings and it is estimated that stocks in the yards of the melters will tide them over through the third quarter. The blast furnaces, however, are carrying practically no stocks and shipments will have to be made from the daily output.

Tests of semisteel and gray iron shells continue encouraging and it is probable that from the data already obtained, specifications can be drawn which will permit a large number of foundries to compete. The practice of the plants that have made experimental shells differs widely and it is certain that the adoption of the best of these methods will establish a standard practice that will facilitate production and will prove economical.

It is probable that both 6 and 8-inch shells finally will be placed on the program of the ordnance department for foundry production and early estimates place the requirements at 12,000,000. This would involve a total of practically 1,200,000 tons of iron and the problem of most difficult solution is where to obtain this supply. The needs of the government are growing apace and in tremendous volume and the 16,800,000 tons of iron and steel required for government needs on contracts, already placed is fast approaching the 20,000,000 mark, or more than a six months' output for the plants of the country.

The change in the production of hand grenades from malleable to gray iron was effected without delay and interruption to the war program. The change was made, it is claimed, because of the great range of the effective pieces into which the malleable grenade was shattered. These were spread, upon explosion, a greater distance than the hand grenade could be thrown and it is certain that this will be overcome with the gray iron missile whose effective pieces are much smaller and probably of not so great a range.

The establishment of the zone system circumscribing the shipment of coal has caused embarrassment for malleable foundries located in Illinois and west of the Mississippi river that have depended upon the low sulphur fuels of Kentucky. The high sulphur coal of Illinois is not adapted to malleable furnace work and it is probable that the foundries so affected will be afforded adequate relief by the fuel administration. The coke supply is plentiful and in some instances it is sufficient to permit of the accumulation of stocks. The quality also has improved and, as a result, the melting practice has been greatly improved. The construction of additional by-product ovens throughout the country will add to the coke supply. Some of these are financed by the government.

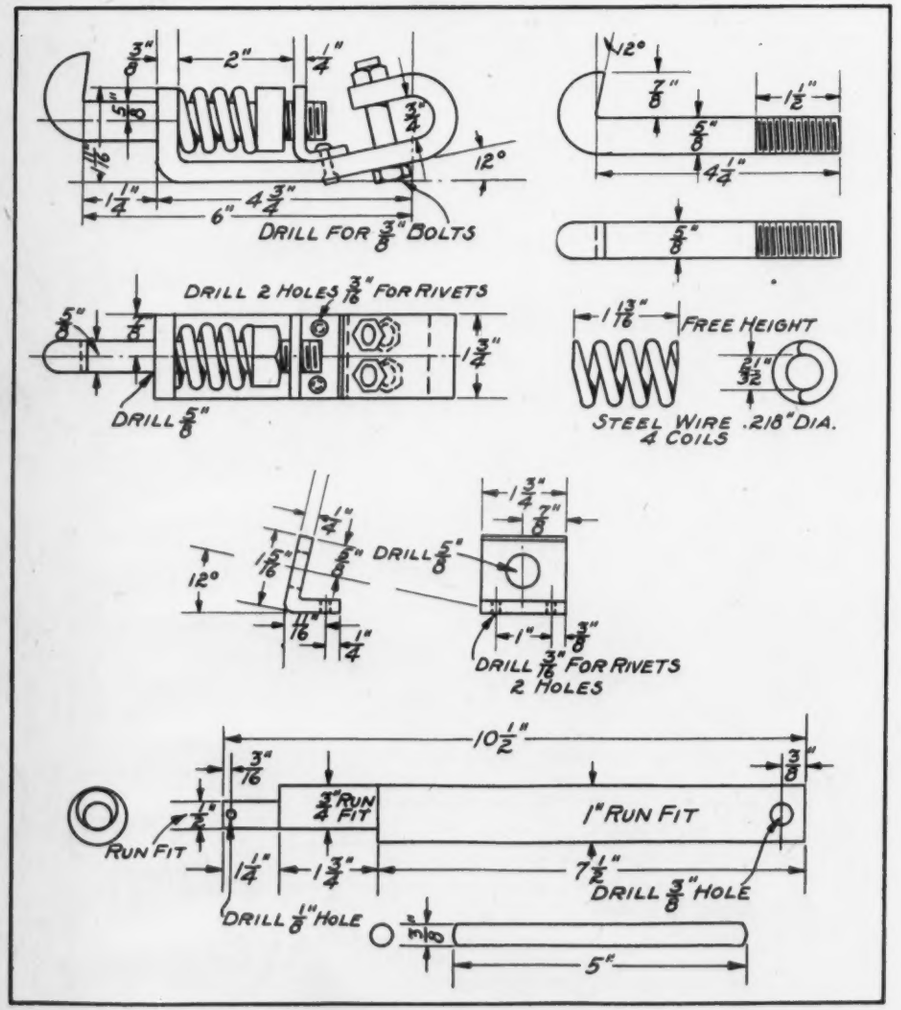
After considerable delay, the casting awards for the 100,000 freight cars and 1025 locomotives, finally have been made by the government. It is estimated that this will involve from 500,000 to 600,000 tons of castings, principally steel and malleable, with a large tonnage of gray iron and brass for the specialties. The American Steel Foundries, Chicago, has received contracts for the cast steel side frames for 35,000 cars, couplers for 23,000 cars and truck bolsters for 46,000 cars. The Buckeye Steel Castings Co., Columbus, O., will furnish the side frames for the freight tenders, truck bolsters for 21,000 cars, couplers for 15,500 cars, side frames for 14,500 cars and draw bar yokes for 50,000. The National Malleable Castings Co., Cleveland, will supply the couplers for 46,000 cars. The Scullin Steel Co., St. Louis, obtained contracts for truck bolsters for 21,500 cars and side frames for 16,000 cars. The Gould Coupler Co., Buffalo, received awards for 8000 truck bolsters, side frames for 6500 cars and 7500 couplers. The Bettendorf Co., Bettendorf, Ia., will furnish 3000 truck bolsters and 28,000 side frames. The McConway & Torley Co., Pittsburgh will make 8000 couplers. The American Brake Shoe & Foundry Co., New York, received the contract for the brake shoes for all of the cars and locomotives. The tender truck bolsters for the 1025 locomotives are to be made by the Pittsburgh Steel Foundry Co., Pittsburgh. The Westinghouse Air Brake Co., Wilmerding, Pa., was awarded the contract for air brakes for 75,000 cars and 775 locomotives and friction draft gears for all engine tenders and 25,000 cars. The New York Air Brake Co., New York, will supply 25,000 car and 250 locomotive air brakes. Numerous other awards also were made for various specialties and equipment requiring an enormous tonnage of all classes of castings. Railroad castings will receive high preference.

Revised Physical Requirements for Army Ordnance Steel Castings

Cast steel	Elastic limit, pounds per square inch	Tensile strength, pounds per square inch	Elongation after rupture, per cent	Contraction of area, per cent
No. 1.....	27,000	60,000	22.0	30.0
No. 2.....	31,500	70,000	18.0	25.0
No. 3.....	36,000	80,000	15.0	20.0

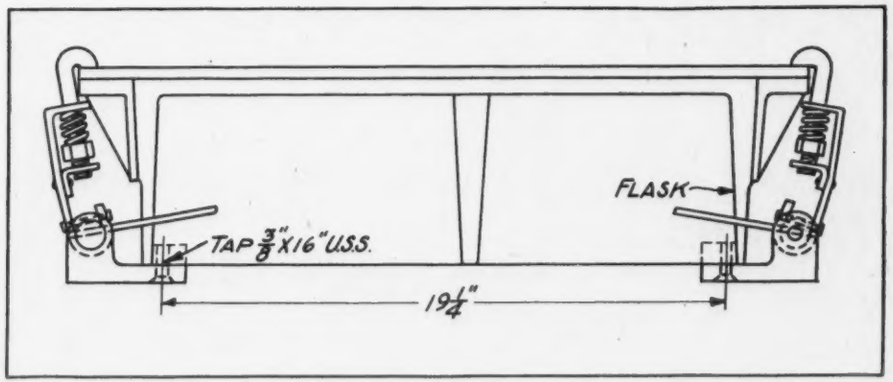
Further concessions in the specifications for steel castings have been granted by the United States bureau of army ordnance which provide for a reduction of the elastic limit for cast steel No. 2 from 32,500 to 31,500 pounds per square inch and for cast steel No. 3 from 42,000 to 36,000 pounds per square inch. Before the recent change in the physical requirements for No. 2 cast steel, the elastic limit was 40,000 pounds per square inch and this downward revision will enable steel casting manufacturers generally to meet this physical property. No changes were made in the tensile strength, elongation or contraction of area. However, cast steel No. 2 may be used in place of cast steel No. 1 in all cases where the latter is called for and cast steel No. 3 may be substituted for cast steels Nos. 1 and 2. This concession will greatly expedite steel foundry operations since it permits the substitution of the higher grades of steel for the lower grades and this will enable foundrymen to pour the higher grades of steel into other molds when desired. It always is difficult to gage a heat exactly and if a heat of No. 3 steel is being made, and in the event of a suprlus amount of this metal after pouring molds in which No. 3 steel is specified, this surplus metal may be poured into molds in which either steels Nos. 1 or 2 are required. The revised specifications also provide that in cases where the carbon content does not exceed 0.35 per cent the phosphorus may run as high as 0.06 per cent with the sulphur 0.08 per cent. In announcing reductions of physical qualities it is stated that these will be granted until further notification only since they are made for the purpose of facilitating the immediate production of steel castings. The physical requirements for steels Nos. 1, 2 and 3, as finally revised, are given in this accompanying table.

CLAMPING DEVICE FOR CORE PLATE



CLAMPING DEVICE FOR CORE PLATE

(Continued from Data Sheet No, 261)



The accompanying illustration shows a core plate clamping device the details of which appear on data sheet No. 262. This device was designed by P. R. Ramp and the engineers of the Moline Plow Co., Moline, Ill. As the illustrations show, the device is quite simple and easily made. It consists substantially of a bracket fastened to the bottom of the flask. This bracket carries an eccentric shaft that is operated by a hand lever. The action of the eccentric shaft draws down a steel plate that carries a hook clamp which projects over the core plate. The hook clamp is provided with a spring and an adjusting nut which relieves undue strain on the eccentric shaft.

THE FOUNDRY DATA SHEET, JULY, 1918

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note-book form.

Win-the-War Methods at the Essington Foundry

How Gray Iron Castings for Ship-Propulsion Machinery Are Made at the Great New Casting Plant of the Westinghouse Electric & Mfg. Co. at South Philadelphia

By E C Kreutzberg

IN JANUARY, 1917, when the Westinghouse Electric & Mfg. Co. authorized the construction of its large new plant at Essington, Pa., there was no indication of the tremendous industrial expansion which was to take place in the Philadelphia district after our entry into the war.

Almost from the beginning, difficulty in obtaining materials, and a most acute labor shortage, proved serious handicaps in the construction and operation of the plant. Necessity, however, served as a spur to astonishing results, and progress was made so rapidly that the first heat in the foundry was poured Nov. 20, 1917. The enormous Essington plant is devoted entirely to the production of ship propelling machinery of the Westinghouse type. Its present capacity is about 75,000 horsepower monthly, or sufficient for 15 average vessels. The product of the plant includes condensers, pumps, turbines, reduction gears, propeller shafting and auxiliary apparatus. In fact, it embraces the entire equipment between the boiler plant and the propeller of a vessel. The only units which as yet are not made at Essington, are the lignum-vitae propeller shaft bearings which are produced at the company's East Pittsburgh plant.

The particular work which now is engaging the Essington plant is the production of complete propelling equipments for the 7500-ton merchant vessels which are being built for the government by the Merchant Shipbuilding Corp. at Bristol, Pa., and for the 3500-ton government merchant vessels which the Submarine Boat Corp. is building at Port Newark Terminal, N. J.

Details of a Great Plant

A COMPARATIVELY brief general description of the great new works of the Westinghouse Electric & Mfg. Co., at Essington, Pa., a suburb of Philadelphia, was published in the June issue of THE FOUNDRY. *This plant is devoted exclusively to the manufacture of ship-propulsion machinery, and as such it is an integral part of the tremendous shipbuilding organization rapidly being developed in this country under the general supervision of the United States Shipping Board Emergency Fleet Corp. Although scarcely six months old, the Essington works has been so thoroughly organized that today its output is nearly three times that considered possible when the plant was designed. The accompanying article is presented to give additional insight into the details of the foundry operations at Essington and to describe the methods and equipment employed to attain a win-the-war volume of production.*

The spirit which stimulated the construction of the Essington plant animates production to such an extent that much has been done to counterbalance the labor shortage by devising equipment and methods which afford the greatest possible output per man. This feature of the plant is illustrated by the work in the foundry. Originally, for instance, it was believed that the greatest possible output of reduction-gear housing castings that could be expected, was four sets of one size per month. Since then, the methods of molding have been so perfected that three sets of reduction-gear housing castings of one size are produced each week, and other castings are being turned out at a proportionate rate.

Typical molding equipment is shown in the accompanying illustrations, which portray the production of a reduction-gear housing base casting, weighing 14,000 pounds. This piece is the lower half of the case which supports and contains the reduction gears between the turbine and propeller shaft on a 7500-ton merchant vessel. The mold consists of a drag and cope and two cheeks, and is put up in a 12 x 14-foot cast iron flask. This flask is 62 inches high. The green sand core is rammed on the drag; the lower cheek is rammed on a pattern

FIG. 1—DRAG AND CORE FOR TURBINE CASING BASE MOLD. NOTE COMPLICATED NATURE OF WORK

FIG. 2—READY TO CLOSE MOLD FOR REDUCTION-GEAR HOUSING COVER-CASTING. FIG. 3—COPE PATTERN FOR EXHAUST-CONNECTION MOLD. FIG. 4—REDUCTION-GEAR HOUSING BASE DRAG AFTER REMOVING CORE BOX. FIG. 5—PATTERN FOR 4000-SQUARE FOOT CONDENSER SHELL SHOWING DRAG AND FIRST CHEEK IN PLACE. FIG. 6—REDUCTION-GEAR HOUSING COVER DRAG WITH PATTERN PARTLY REMOVED

mounted on a plate, the second cheek also is rammed on a pattern mounted on a plate, and the cope is rammed on the second cheek. Numbers of gaggers are required and a considerable quantity of coke is used to adequately ventilate the mold. The mold has two gates, one on each end, and four risers. It is dried in an oven before closing. The thickness of metal in this casting is 1 inch in the web, while the flanges have a thickness of about 2 inches. The mold for the reduction-gear housing cover casting, which weighs 9000 pounds, consists only of cope and drag; the core is rammed on the drag, while the cope is rammed on a separate pattern mounted on a plate. The mold then is dried before closing. The production of these reduction-gear housing castings now is three sets per week of the 7500-horsepower size. In addition one set of reduction-gear housing castings for 3500-horsepower vessels is produced daily by this method.

FIG. 7—ASSEMBLING TURBINE-CASING BASE AND COVER CASTINGS

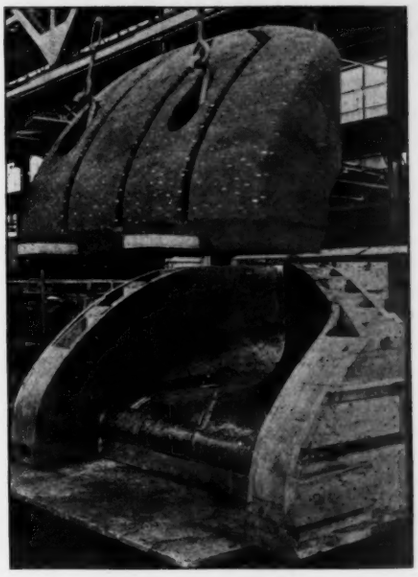


FIG. 8—LIFTING MAIN CORE FOR EXHAUST-CONNECTION MOLD

Equally interesting is the method of producing condenser-shell castings. In the propelling equipment of each 7500-ton vessel, a 4000 square-foot condenser shell is required. It consists of two castings. Each weighs about 6000 pounds. One serves as the inlet and the other as outlet, and the only difference between them is that one is right and the other left. Originally both castings were produced from one pattern which was changeable but separate patterns now are used. As shown in Fig. 28, the mold is comprised of drag, two cheeks and a covering cope. It is molded in an iron flask, 8 feet square and 68 inches high. The drag and cheeks are rammed on a bottom plate and the cope on a flat plate. The core is rammed separately. The corebox is placed on a plate, and the barrel placed on the inside of the corebox, leaving approximately 3 inches of sand at the bottom and about 8 inches of sand at the top. Then it is put on the jarring machine and rammed, after which the box is pulled off. After it has been dried, the core is placed in the mold on an iron print, or socket, which is bolted to the bottom plate after the pattern has been drawn. The barrel is pushed out of the casting about 25 minutes after it has been poured, by the use of a toggle, while the casting still is in the flask. The mold is dried before closing and is poured through two gates. One set of these castings is being produced daily. Condenser shells for 3500-ton vessels also are produced by the same method, at the rate of one set daily.

Another casting in the production of which considerable ingenuity has been exercised is one that serves as the exhaust connection between the

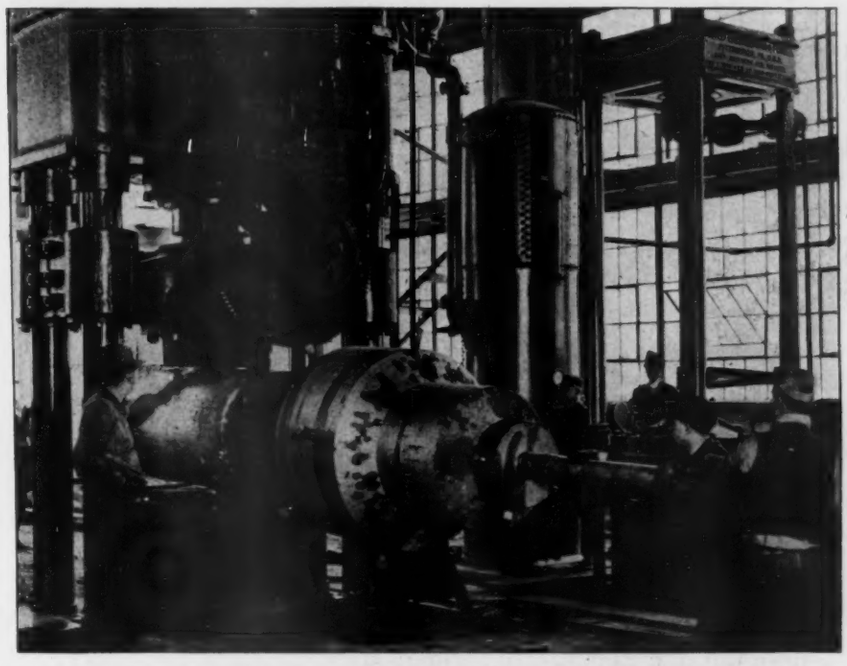


FIG. 9—1000-TON STEAM-HYDRAULIC PRESS FOR MAKING PROPELLOR-SHAFT FORGINGS

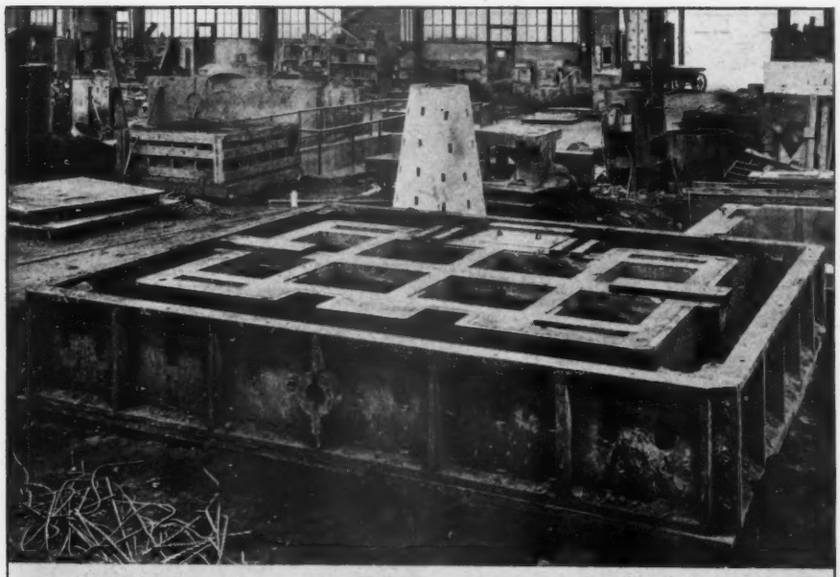


FIG. 10—PATTERN AND FLASK FOR MAKING FIRST CHEEK FOR REDUCTION-GEAR HOUSING BASE CASTING. FIG. 11—MAIN CORE FOR 4000-SQUARE FOOT CONDENSER CASTING, SHOWING CORE BOX. FIG. 12—PATTERN FOR MAKING SECOND CHEEK FOR REDUCTION-GEAR HOUSING BASE MOLD

condenser and the turbine on a 7500-ton vessels. This casting weighs about 9500 pounds and the mold consists of a drag and cope. These are shown in Figs. 3 and 8. They are rammed on separate patterns which are placed on matchboards. The drag is rolled over, while the cope, after ramming, is lifted off and finished overhead while suspended from a crane. The core is made separately and lifted off the box. The mold is dried before closing, and is provided with one gate. The iron flask in which this casting is molded is 10 x 10 feet, and 12 feet high; it is jointed to conform to the shape of the casting. Three of these castings are produced each week.

Turbine castings are molded by equally efficient methods, although the practice is less spectacular. In Figs. 1 and 15 is shown the mold for the base section of a turbine for a 7500-ton vessel. The mold, which consists of cope and drag, is dried before closing. This casting weighs 8000 pounds. The casting which forms the top half of a turbine casing is molded in a drag, cheek and cope. The drag is rammed on a print. The cheek is rammed on a pattern which is mounted on an iron plate, and the cope is rammed on the cheek. Production of these castings is at the rate of one set per day, while one set for 3500-ton vessels also is produced daily.

Separate Light Casting Floor

A portion of one of the side bays at the Essington plant is devoted to the production of the lighter casting for marine propulsion systems. This section of the shop is equipped with six pneumatic, rollover, molding machines and several small jar-ramming machines. In the production of heavy castings, the only machines employed are two 15-ton jolt-rammers. A great deal of the ramming, however, is done by pneumatic hand tools. Manipulation of the heavy molds is accompanied entirely by means of cranes. To facilitate rolling over the large molds, three rollover beams have been built, 12, 14 and 16 feet in length, respectively. Each crane has two trolleys, so that when flasks are wider than 16 feet, the cranes may be used for lifting and rolling. The main foundry bay, in which the heavy work is done, is provided with one 100-ton and two 60-ton, 80-foot span cranes, together with six 5-ton jib travelers. The north bay, which is 50 feet wide, contains one 30-ton and two 20-ton cranes. The south bay, 30 feet wide, contains one 20-ton and one 30-ton crane.

For drying cores and molds, the north bay is provided with ten

24 x 32 x 22-foot, and six 5 x 12 x 12-foot, together with one drawer-type oven. The 10 large ovens, which are double-tracked, accommodate four cars each, while the six smaller ovens have single tracks and accommodate two cars each. The cars are moved in and out of the ovens by chain cables which are operated by means of clutches from a motor-driven line shaft in the floor of the main bay. In addition to the ovens, the foundry is equipped with twelve coke-burning, forced-draft, portable dryers, which are used for drying floor and pit molds.

In order to conserve floor space, molding sand is supplied to the foundry in a novel manner. In the sand-mixing department it is dumped into steel boxes, which are loaded on storage battery trucks and taken through tunnels into the foundry. The sand boxes are then lifted through hatchways in the foundry floor by means of a crane, as shown in Fig. 26. The sand department is located in the basement of the pattern-storage building which is immediately adjacent to the foundry. Here are bins which have capacity for storing 120 carloads of sand where it will not be exposed to the weather. This department is equipped with five sand mills. Adjacent to the foundry is a building which is devoted to reclaiming waste sand from the cleaning room.

Why Air Furnaces are Used

About 250 tons of gray iron per day is the capacity of the melting equipment at the Essington plant. This includes the melt of three cupolas and three air furnaces. Two of the cupolas are 66 inches in diameter inside the lining and the third is 60 inches. Two of them are equipped with charging machines, as shown in Fig. 14. Two of the air furnaces have capacity of 40 tons each and the third has a capacity of 15 tons. The air furnaces, which burn bituminous coal, were installed for two reasons; large, unbroken pieces of scrap may be charged into them, and the entire heat is available at one time. The latter advantage becomes exceedingly valuable when it is necessary to provide iron for an extraordinarily large casting. After charging, about eight hours elapses before a heat can be taken from the 40-ton furnaces. All the metal is poured from crane ladles. The heats from the air furnaces are received in ladles which are located in pits. The foundry is equipped with a chemical laboratory where the mixtures are made. Pig iron, scrap iron and coke

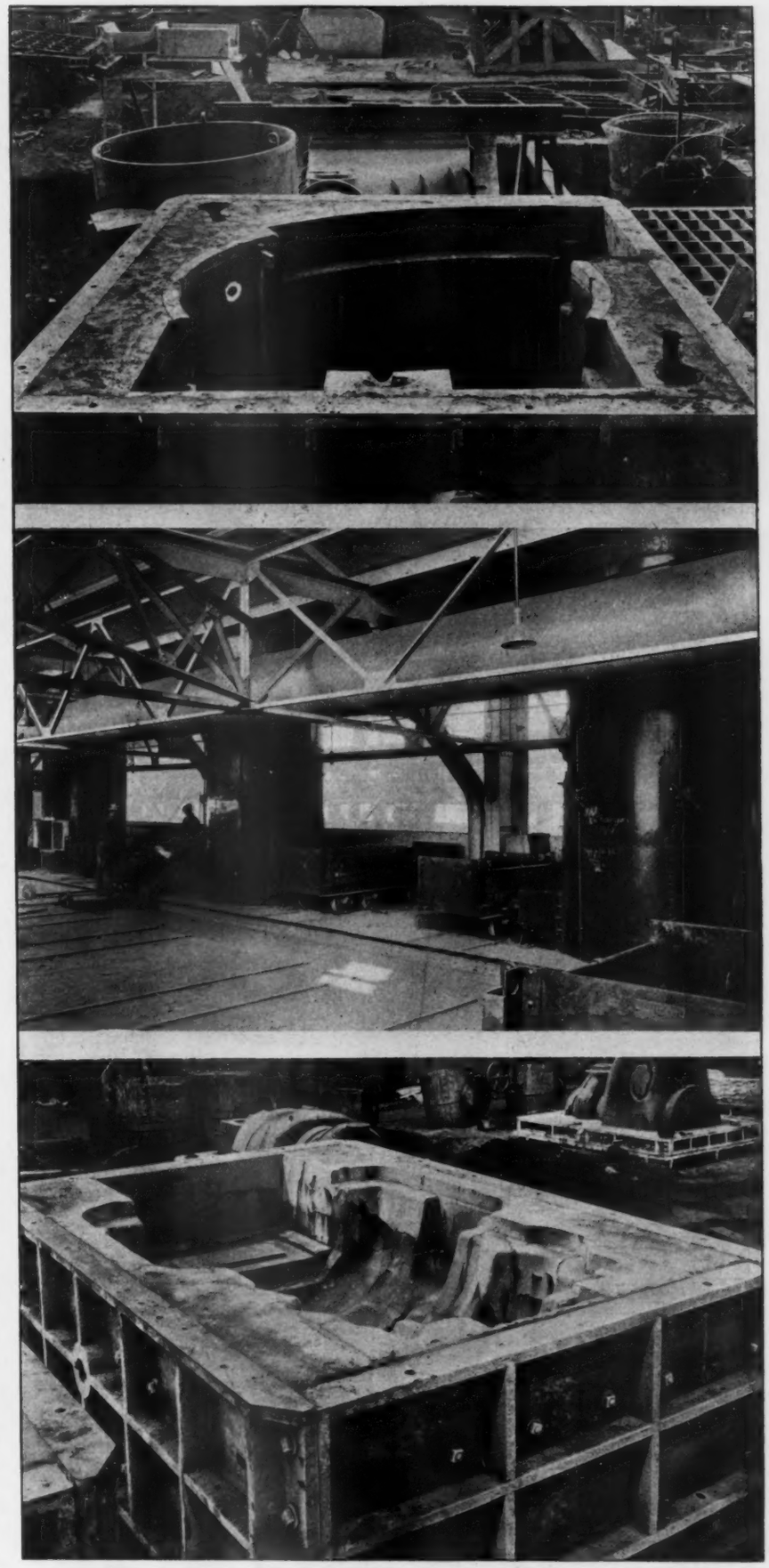


FIG. 13—MOLD FOR 4000-SQUARE FOOT CONDENSER SHELL BEFORE PLACING CORE. FIG. 14—TWO OF THE CUPOLAS ARE EQUIPPED WITH CHARGING MACHINES. FIG. 15—COPE FOR TURBINE CASING BASE MOLD

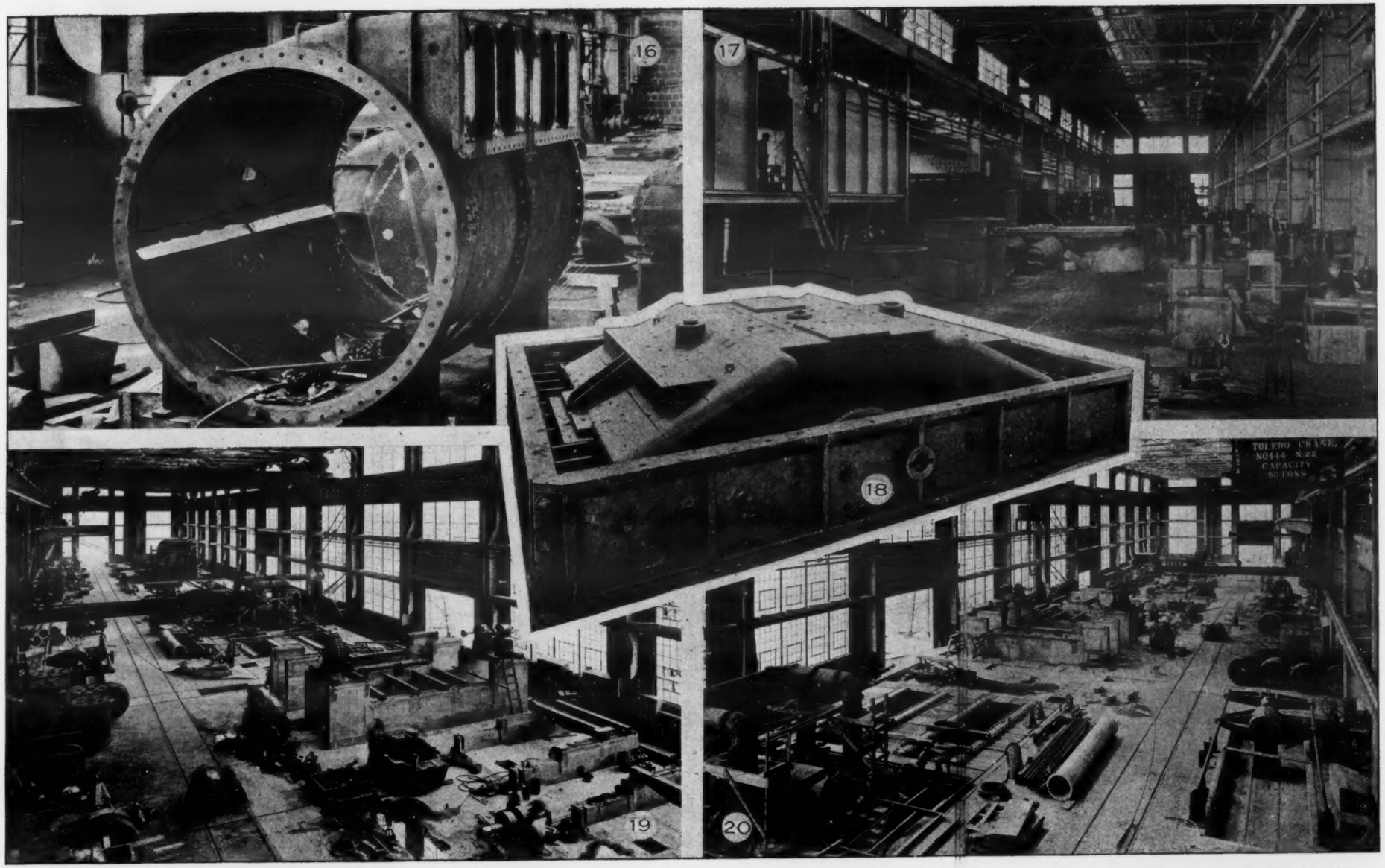


FIG. 16—ASSEMBLING INLET AND OUTLET SECTIONS INTO A COMPLETE CONDENSER SHELL. FIG. 17—FORGING SHOP FOR PRODUCING PROPELLER SHAFTING AND OTHER FORGINGS FOR SHIP PROPULSION MACHINERY. FIG. 18—REDUCTION-GEAR HOUSING COVER COPE PATTERN WITH FLASK. FIG. 19—ERECTING SHOP SHOWING PARTIALLY COMPLETED PITS FOR TESTING TURBINES WITH PRONY BRAKES. FIG. 20—ANOTHER VIEW OF ERECTING SHOP SHOWING HYDRAULIC PRESS FOR ASSEMBLING TURBINES AND CONDENSER FOR USE IN TESTING THEM

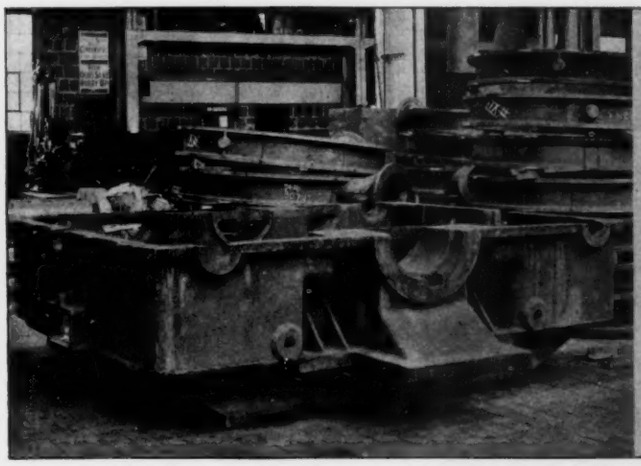


FIG. 21—REDUCTION-GEAR HOUSING BASE CASTING READY TO BE MACHINED

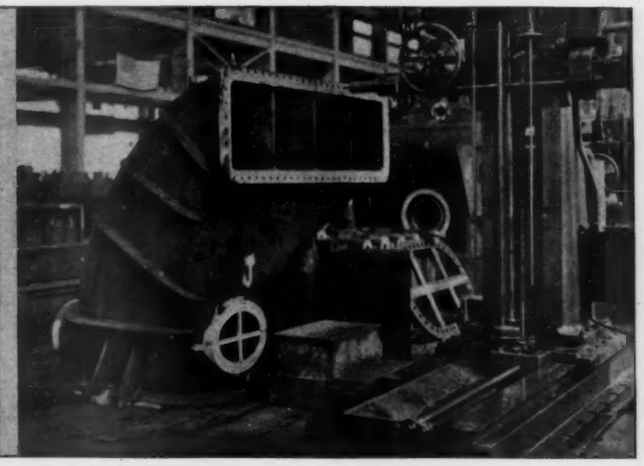


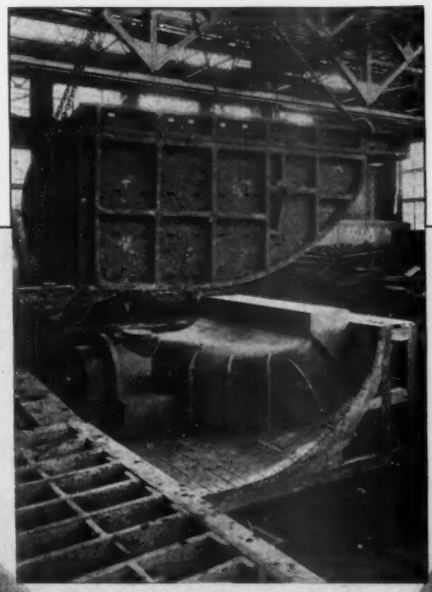
FIG. 22—MACHINING AN EXHAUST-CONNECTION CASTING ON A HORIZONTAL BORING MILL

are loaded into cars in the storage yard, weighed, and brought to the charging platform by elevators. For emergency use, the charging floor also is provided with an outside platform which is commanded by a crane. This crane has capacity for 60 tons and span of 100 feet. It is mounted on a 660-foot runway.

In the north bay of the foundry is situated a fair-sized brass, bronze and aluminum melting department. The equipment includes six, coke-burning, crucible furnaces, and one oil-burning furnace. The entire non-ferrous capacity is about 4000 pounds per heat.

The foundry is provided with a machine-repair department. This is located on the first floor of the pattern storage building and is employed chiefly for making repairs to iron flasks, molding machines, and cranes. Its equipment includes a shaper, two lathes, a drill press, a bolt and pipe threader, hacksaws, a milling machine, grinder, radial drill, etc. In the pattern-storage building is also located a wood-flask shop which is operated by the foundry department.

The pattern shop and pattern storage building at present is used for a number of purposes, owing to the



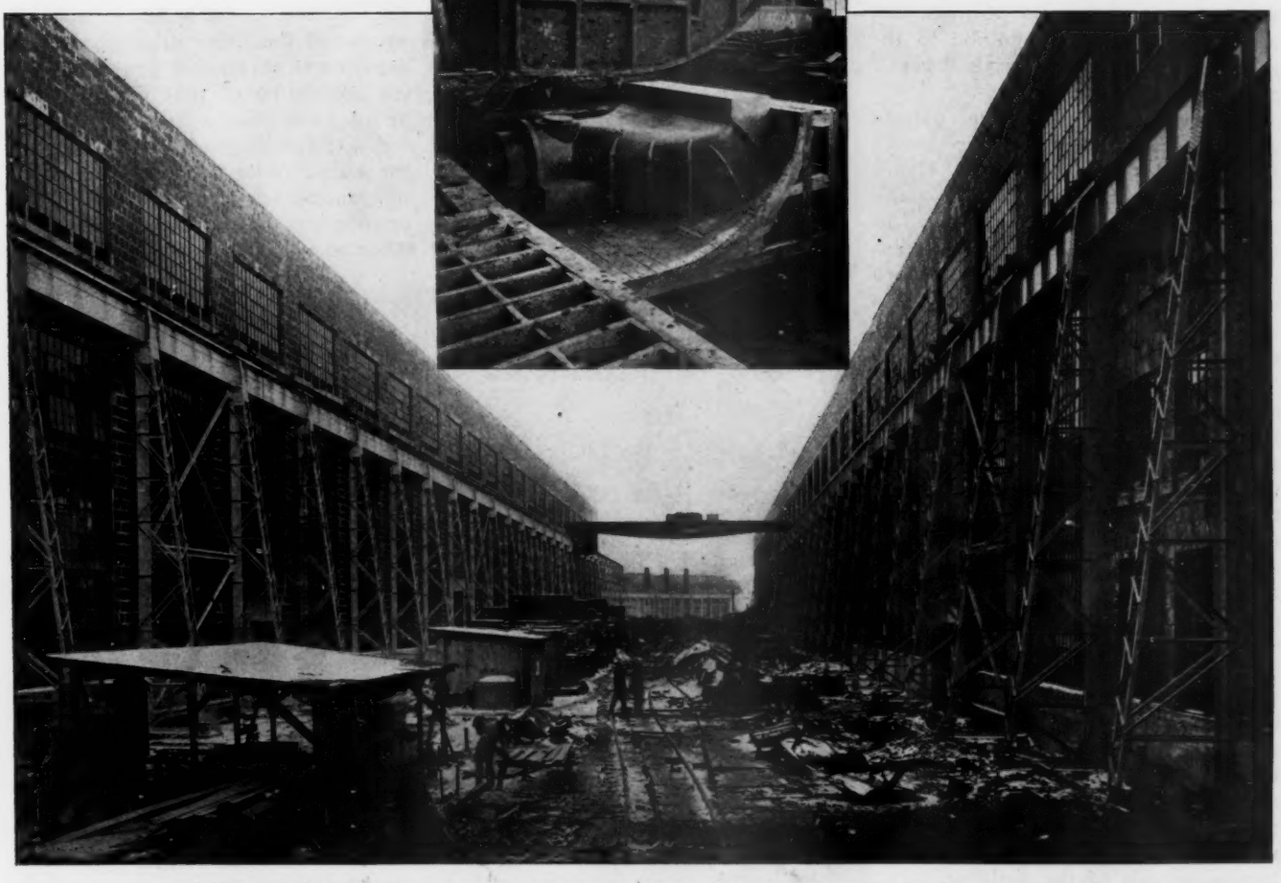


FIG. 23—DRAG PATTERN FOR EXHAUST-CONNECTION MOLD READY TO PLACE FLASK.
FIG. 24—CRANE RUNWAY BETWEEN MACHINE SHOPS LOOKING TOWARD FOUNDRY

FIG. 25—EXHAUST CONNECTION DRAG

fact that the patterns as yet have not accumulated sufficiently to take up much room. This structure is 135 x 400 feet, four stories high and is of reinforced concrete construction. In order to reduce fire risk to a minimum, the stairways and elevators are located outside of the building proper. In adddition to the pattern shop and pattern storage,, this building temporarily contains the main offices of the plant, a cafeteria and dining room, a first-aid hospital, and a large tool room, in addition to the sand storage, foundry machine-repair and wood flask departments.

A novel feature of the pattern shop is its location on the fourth floor of this building. This choice was made in order to afford a maximum amount of natural light. In order that even the largest patterns may be removed from the pattern shop with facility, the building has been provided with a 20 x 20-foot elevator which has a capacity of 10 tons. The equipment in the pattern shop is unusually varied and complete; it comprises a number of tools which are not found in most shops of this kind. Among them are two universal woodworking machines for milling patterns to any desired form; a "ship" bandsaw which may be set accurately at any angle and has capacity for sawing through 24 inches; dowel machines, swinging cut-off saws, universal wood grinders, tool and saw-tooth grinders of all kinds, and the usual run of patternmaking machinery and apparatus. All machines are motor-driven and are equipped with safety devices. The pattern shop is provided with a dustcollector system which discharges into an incinerator located outside of the building.

The other principal departments of the Essington plant, in addition to the pattern shop, pattern storage and foundry, are the forge and machine shops, erecting floor and power plant. The forge shop is 50 x 350 feet, the two machine shops are each 120 x 750 feet and the erecting shop is 130 x 550 feet. The whole plant consists of steel, brick and hollow-tile buildings, adequately lighted and ventilated, which are laid out to permit the indefinite extension of each department, without derangement of the manufacturing scheme. The thoroughness with which all details of construction were considered is reflected in the fact that all of the buildings are connected by well-ventilated, reinforced-concrete tunnels, which not only serve as conduits for water, steam, compressed-air and electric-current leads, but are large enough to afford communication from one building to another.

An elaborate system has been developed for keeping track of the work in all its stages, and in all departments of the plant. This system is designed to focus the attention of the production department uniformly upon all parts of each propelling unit, since neglect of any particular part might result in chaos at the shipyards. The keystone of the manufacturing organization, therefore, is an engineering department which divides up each order as it is received and apportions it among the various producing departments. The engineering department first supplies the pattern department with preliminary information which enable it to make such new patterns as are needed. It then turns over to the supply and order department a complete list of drawings, arranged by departments, which constitute a sort of cross index to the materials which will be needed in each department for turning out the order. Having a record of the materials which are on hand in each department, the supply and order department at once is in a position to order what is needed. Two forms then are sent to each department showing what work it is to do in connection with this particular order; one of them is on a time-department sheet and the other on a production-department sheet, thus providing both for accounting of time and following up of production. It is the duty of the director of production to analyze the entire order from the standpoint of productive capacity, after which he notifies the foremen of the date when the work in each department

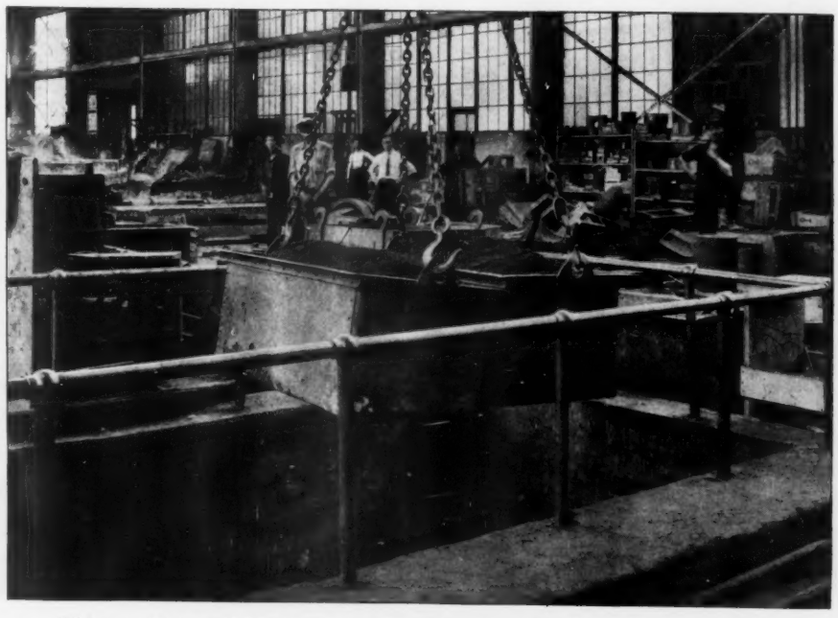


FIG. 26—HOW MOLDING SAND IS BROUGHT INTO THE FOUNDRY

must be done. By means of clerks or chasers in each department, he constantly posts the foremen as to what parts have priority. In addition, the director of production calls a meeting of the foremen every few days to discuss all factors that have a bearing upon the progress of the work. By this system it generally is possible to tell in advance when a particular department is liable to fall behind its schedule, and steps may be taken to overcome the difficulties before they lead to serious trouble.

The machine shops parallel each other and communicate directly with the erecting shop, extending from the latter at an angle of 45 degrees. This permits the railroad tracks from the machine shops to enter the erecting shop with a minimum of curvature. This arrangement also affordss space for departmental offices, which are located in 4-story buildings occupying the triangles formed by the junction of the machine shops with the erection shop.

The floor of No. 1 machine shop is occupied by large tools for machining large condenser bodies, condenser tube plates, condenser covers, large reduction gears, propeller shafting, etc. From the standpoint of machinery, the floor is divided into departments. One of the most important is a lathe department where all line and tail shafting and reduction-gear shafts and pinions, are machined. Another is a drill-press department, where condenser and pump parts are drilled. Other departments contain standard planers, rotary planers, horizontal drill presses, etc. No. 1 machine shop has a balcony which is equipped with screw machines and other tools for handling the lighter work on pumps, condensers and reduction gears. The balcony also is provided with a machine-repair department. No. 2 machine shop is devoted to the machining of turbines. The floor of this shop is occupied by the planer, vertical boring mill, lathe, drill press, horizontal-boring mill and gear-hobbing departments. The gear-hobbing section is equipped with large machines capable of milling teeth on gear wheels up to 160 inches in diameter. These hobbing machines were made by the company at its East Pittsburgh plant, especially for its own purposes. The balcony in No. 2 machine shop is devoted to the machining of lighter work on turbines. All machines throughout these shops are provided with individual motor drive. Each machine shop is provided with 11 cranes ranging in capacity from 3 to 50 tons. In addition to standard-gage railroad tracks which extend through the shops and on which large electric trucks operate, the machine shops are provided with numerous small storage battery floor trucks. The floors in the machine and erecting shops are of asphalt blocks. The space between the machine shops is spanned by a crane and is devoted to the storage of castings which are to be machined. A novel feature is the use of concrete pits, located in the yard, for the storage of borings and turnings. As they accumulate, they are removed from the pits by a magnet and loaded into cars. Brass borings and turnings are kept separate. The erecting shop which is shown in Figs. 19 and 20 has been provided with pits and foundations for testing turbines and other propelling machinery after erection. These pits are permanently constructed and are provided with pipe connections. For conducting the tests, large quantities of water are required. The water is pumped from the Delaware river and is passed through a settling basin. The erecting shop contains balancing machines for conducting balancing tests upon different parts of turbine spindles. It also contains a jacket department, for making sheet-steel jackets for turbines, and a pipe department.

A completely equipped forge shop has been provided for producing propeller shafting. The principal unit which is shown in Fig. 9 is a 1000-ton steam hydraulic press. The forge shop also contains a 350-ton steam-hydraulic press, a 1500-pound steam ham-

(*Concluded on page* 340)

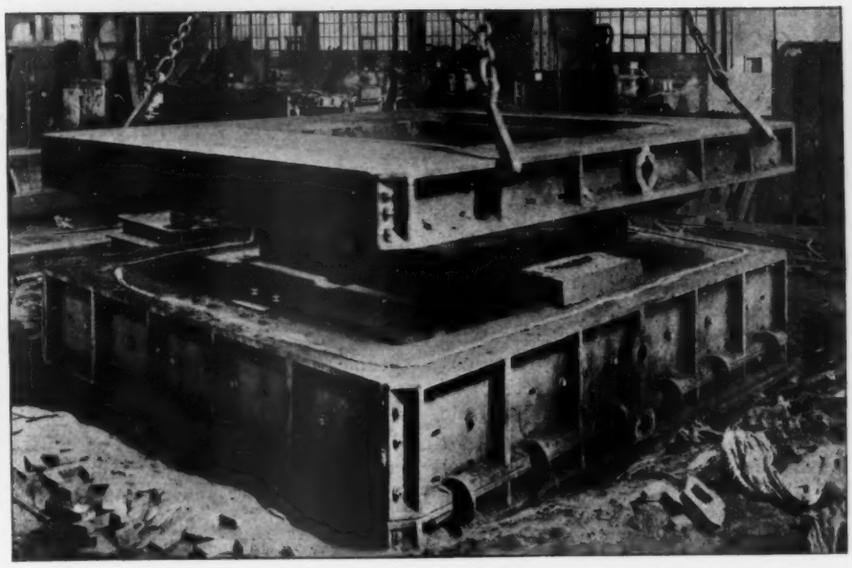


FIG. 27—REDUCTION-GEAR HOUSING BASE MOLD JUST BEFORE CLOSING

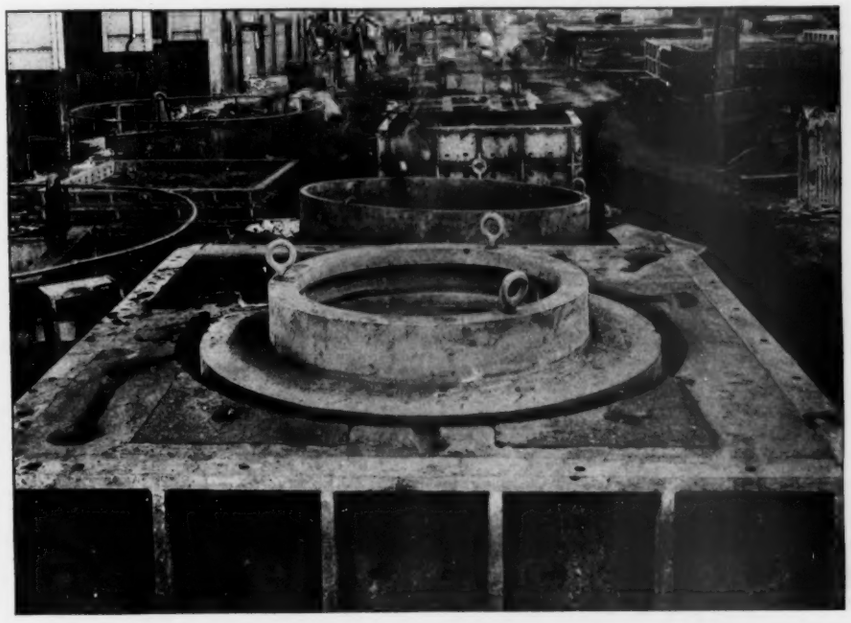


FIG. 28—PARTLY CORED MOLD FOR 4000-SQUARE FOOT CONDENSER SHELL

Testing Engineers Discuss Nonferrous Metals

Specifications Are Considered for Babbitt Metal and Bronze Bearings for Turntables and Movable Railroad Bridges—Season Cracking of Brass

CONSTANTLY growing interest is being manifested by the American Society for Testing Materials in the preparation of standard specifications for nonferrous metals and alloys. At the twenty-first annual meeting of this organization, held at Atlantic City, June 25-28, a number of new standards for nonferrous alloys were submitted and the topical discussion on season and corrosion cracking of brass aroused considerable interest. Also, for the first time in the history of this body, a foundryman has been elected to the office of president. Gulliam H. Clamer, first vice president and secretary of the Ajax Metal Co., Philadelphia, was elected to this exalted office. The report of the committee on nonferrous metals and alloys probably was the most comprehensive yet presented. Accelerated manufacture of ammunition has pointed to the need of standards for cartridge brass, cartridge brass discs and naval brass rods for structural purposes and tentative specifications for these three materials were submitted for consideration. Numerous changes also were made in the tentative specifications for the sand cast alloy consisting of copper, 88 per cent; tin, 10 per cent and zinc, 2 per cent. A new section was added to this specification which provides that an analysis of each melt shall be made by the manufacturer. The chemical composition thus determined shall be reported to the purchaser or his representative. This specification also has provided for a tensile strength of 33,000 pounds per square inch with an elongation in 2 inches of 14 per cent. The tensile strength, however, was reduced to 30,000 pounds per square inch, a yield point of 15,000 pounds per square inch was introduced, while the elongation remains at 14 per cent. The paragraph of this standard referring to materials which do not conform to the specifications, as indicated by the purchasers' tests and which provides for a retest, has been changed considerably. The new clauses state that inspection may be made at the manufacturer's works where the castings are produced, or at the point at which they are received, at the option of the purchaser. "If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works, which concern the manufacture of the material ordered. The manufacturer shall afford the inspector free of cost all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. The castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected and if rejected shall be replaced by the manufacturer free of charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer." Proposed tentative specifications for bronze bearing metals for turntables

GUILLIAM H. CLAMER
President-Elect, American Society for Testing Materials

Guilliam H Clamer

GUILLIAM H. Clamer, president-elect of the American Society for Testing Materials, ranks as one of the foremost metallurgists in the world in the nonferrous casting industry. Although only 43 years of age, his accomplishments in this special field have been many and of great importance to the trade and his work has received well-merited recognition throughout the scientific world. Mr. Clamer was born in Philadelphia where he is still located, being affiliated with the Ajax Metal Co. in the capacity of first vice president and secretary. He is a product of the public and manual training high schools of Philadelphia from which he graduated in 1891 and during the following two years he worked in the private chemical laboratory of Dr. F. A. Genth. During this period he also served as substitute teacher in the manual training schools in the departments of chemistry, electricity and mechanical drawing. He entered the University of Pennsylvania as a special student in chemistry in 1893, finally working into the regular course. He graduated in 1897.

After leaving school he immediately entered the employ of the Ajax Metal Co. in the capacity of chemist and his efficient work was recognized by frequent promotions resulting in his election to the offices of first vice president and secretary. Mr. Clamer is believed to be the first chemist regularly employed in the brass and bronze business. Two decades ago the value of chemical analysis was little appreciated in the nonferrous casting industry and even the brass rolling mills questioned whether a chemist would be of value to them. However, Mr. Clamer soon demonstrated his usefulness and before many years elapsed he proved that a chemist was indispensable to the conduct of the brass foundry. In 1898 he began the study of metallography and was counted among the pioneers in the metallographic study of the nonferrous metals. As a direct result of these investigations, Ajax plastic bronze, a copper, tin and lead alloy was developed, which contains a high percentage of lead and is employed extensively for railroad bearings. He also developed a process for eliminating zinc, aluminum and iron and other metals electropositive to copper, tin and lead from alloys containing all of these metals, and for this investigation he was presented with the Eliott-Cresson gold medal, which is the highest award of the Franklin institute. He also has been associated with Dr. Carl Hering, James Wyatt and Dr. Edwin F. Northrup, of Princeton university in the development of electric furnaces, particularly of the induction type, using both low and high frequency currents, alternating and oscillatory. As a result of this work several distinct types of electric furnaces have been developed which have proved to be commercially successful for brass melting.

Mr. Clamer has held many high executive offices in various technical bodies. He is a past president of the American Institute of Metals, now the Metals division of the American Institute of Mining Engineers and of the Mining and Metallurgical section and Committee on Science and the Arts of the Franklin institute. He is a member of the board of the Franklin institute and of its committee on Science and the Arts; chairman of the committee of the Institute of Metals appointed to co-operate with the United States bureau of standards and also is a member of its board. He is chairman of the committee on white alloys of the American Society for Testing Materials and also is affiliated with its committees on papers and nonferrous alloys. When the war service committee of the American Foundrymen's association was appointed he was selected as the member to represent the nonferrous casting industry and he also is affiliated with practically all the leading technical societies of the United States and England.

and movable railroad bridges also were submitted, which are based on those of the American Railway Engineering association and were modified at the convention of this organization held several months ago. Tentative specifications for white metal bearing alloys, known commercially as babbitt metal, also were submitted. These embrace a series of 12 alloys which may be modified as experience may dictate. An interesting and valuable table giving the physical properties of these bearing alloys also is included in these specifications. Tentative specifications for copper plate for locomotive fire boxes, for copper bearings for locomotive staybolts, for seamless copper boiler tubes and for seamless brass boiler tubes were referred to letter ballot for adoption. G. H. Clamer, chairman of the subcommittee on nonferrous alloys for railway equipment, recommended numerous changes in the tentative specifications for nonferrous alloys for railway equipment in ingots, castings and finished car and tender bearings. He recommended that the four bearing metals be changed to three and these specifications remain tentative because there is still some doubt as to the proper limits of the composition of these alloys. The members of this committee are convinced of the desirability of having a hard alloy for the bearings which are subjected to alternating or impact blows. A softer alloy than bearing metal No. 2 for driving brass, truck brasses and hub liners was agreed to and since it was the unanimous opinion of the committee members that the zinc content of 5 per cent in bearing metal No. 4 was too high for the best practice, it was decided to compromise between alloys Nos. 3 and 4 and the maximum zinc content recommended is 2.50 per cent. A sweeping change was recommended in the paragraphs referring to the purposes for which these bearing alloys are used and in the revised tentative specifications bearing metal No. 1 will be for connecting rod bearings, bushings, eccentric straps, crosshead jibs and miscellaneous bushings. Bearing metal No. 2 for drive box bearings, government truck and trailer bearings and hub liners and bearing metal No. 3, for lead-lined bearings for locomotive tender, freight and passenger car equipment. The table of chemical compositions naming only three bearing metals instead of four has been changed as shown by Table I, shown on this page. Work already has been commenced on the preparation of tentative specifications for aluminum ingot, aluminum sheet and aluminum for castings. The international aircraft standards board it is stated, already has done considerable work along this line, having adopted a number of specifications in co-

Table I

REVISED COMPOSITION OF NONFERROUS ALLOYS FOR RAILWAY EQUIPMENT IN INGOTS, CASTINGS AND FINISHED CAR AND TENDER BEARINGS

Alloy	Copper, per cent	Tin, per cent	Lead, per cent	Zinc, max., per cent	Iron, max., per cent	Antimony, per cent	Phosphorus, max., per cent	Sulphur, max., per cent	Arsenic, max., per cent	Total impurities, including zinc, max., per cent
Bearing metal No. 1	§	9–11	9–11	0.75	0.25	0.25*	1.0†	....	....	1.0
Bearing metal No. 2	§	4–6	23.5–26.5	0.75	0.40	0.50*	....	....	....	1.5
Bearing metal No. 3	§	4–6	17–22	2.50	0.40	0.50*	....	....	....	3.0
Bell metal ...	§	16–18	0.25*	0.25	0.25	0.25*	0.02	0.05	....	0.50
Babbitt metal.	0.50*	9.25–10.75	§	none	....	14–16	....	....	0.20	0.75‡
Lining metal..	0.50*	4.50– 5.50	§	none	....	9.25–10.75	....	....	0.20	0.75‡

*Maximum.
†Not considered an impurity, and can be specified at option of purchaser.
‡Must not contain zinc.
§Remainder.

operation with representatives of the allied governments and with manufacturers. Among these specifications are the following: Ingot and

by the society as tentative. These methods are used in the laboratories of some brass and bronze producers and will be tested critically by mem-

discussion that considered every phase of this subject. It was formally introduced by the following speakers who discussed various features of this

Tentative Specifications for Bronze Bearing Metals for Turntables and Movable Railroad Bridges

1.—(*a*) These specifications cover four classes of bronze bearing metals for turntables and movable railroad bridges.

(*b*) The purposes for which these classes are frequently used are as follows:

Class A, for contact with hardened steel disks under pressures over 1500 pounds per square inch, for example, bearing metals, used in turntables and center-bearing swing bridges;

Class B, for contact with soft steel at low speeds under pressures not over 1500 pounds per square inch, for example, trunnions and journals of bascule and lift bridges;

Class C, for ordinary machinery bearings;

Class D, for gears, worm wheels, nuts and similar parts which are subjected to other than compressive stresses.

2.—(*a*) The bronze shall be a homogeneous alloy of copper and tin. The copper shall conform to the requirements of the standard specifications for electrolytic copper wire bars, cakes, slabs, billets, ingots and ingot bars, or the standard specifications for lake copper wire bars, cakes, slabs, billets, ingots, and ingot bars, "high resistance" grade, of the American Society for Test-

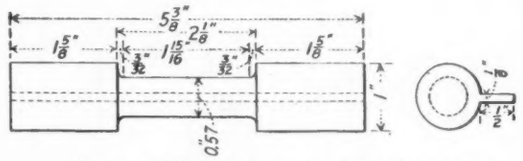


FIG. 1—TEST BAR FOR TENSION TEST

ing Materials. The bronze shall be made from new metal, except that scrap of known composition produced by the foundry at which the bronze is cast may be used.

(*b*) Care shall be exercised that the metal is not overheated and that the temperature at pouring and the conditions of cooling are such as will be most likely to secure dense castings.

3.—The bronze shall conform to the following requirements as to chemical composition:

Elements considered, per cent:	Class A	Class B	Class C	Class D
Copper	about 80	about 83	about 80	about 88
Tin	about 20	about 17	about 10	about 10
Lead	.....	.....	about 10	not over 0.5
Zinc	.....	.....	.....	about 2
Iron	.....	.....	.....	not over 0.2
Phosphorus	not over 1.0	not over 1.0	0.7-1.0	.....
Other elements	not over 0.5	not over 0.5	not over 0.5	not over 0.5

4.—(*a*) An analysis of each melt may be made at the option of the purchaser and at the purchaser's expense. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

(*b*) The compression test coupon shall be used for analysis.

5.—(*a*) The bronze shall conform to the following requirements as to compressive and tensile properties:

Properties considered	Class A	Class B	Class C	Class D
Compression				
Deformation limit, lb. per sq. in.	25,000-40,000	19,000-23,000	12,000-17,000	about 14,000
Permanent set in 1 in. under 100,000 lb. per sq. in., in.	0.06-0.10	0.12-0.25	.....	.....
Tension				
Yield point, min., lb. per sq. in.				15,000
Tensile strength, min., lb. per sq. in.				30,000
Elongation in 2 in., min., per cent				14

(*b*) The deformation limit in compression shall be determined as that load which produces a permanent set of 0.001 inch in the compression test specimen described in Section 6 (*b*).

(*c*) The yield point in tension shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 inch in a gage length of 2 inches.

6.—(*a*) A test bar of the form and dimensions shown in Fig. 1, to be used for the tension test specimen, and a suitable test bar for the compression test specimen, shall be an integral part of the casting, and shall be fed and cooled under the same conditions as the castings.

(*b*) Compression test specimens shall be cylinders 1 square inch in cross-sectional area and 1 inch high.

(*c*) Tension test specimens, turned from the test bar shown in Fig. 1, shall conform to the dimensions shown in Fig. 2. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

7.—(*a*) One compression test shall be made from each melt for Class A, B and C castings; and one compression and one tension test from each melt for Class D castings. For castings of any grade weighing over 100 pounds finished, the specified tests shall be made for each casting.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer

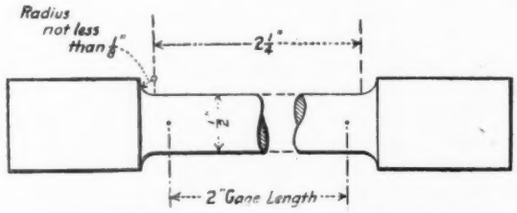


FIG. 2—TENSION TEST SPECIMEN TURNED FROM FIG. 1. GAGE LENGTH, PARALLEL PORTIONS AND FILLETS SHALL BE AS SHOWN; ENDS OF ANY FORM TO FIT HOLDERS OF TESTING MACHINE

and the purchaser or his representative shall agree upon the selection of another specimen in its stead.

8.—The castings shall be sound, clean, and free from blowholes, porous places, cracks and other defects.

9.—(*a*) Inspection may be made at the manufacturer's works where the castings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

10.—Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected, shall be replaced by the manufacturer free of charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

sheet aluminum, aluminum alloy sheet castings and tubing.

Methods for the chemical analysis for manganese bronze and gun metal were submitted and will be published

bers of the committee and other chemists who have consented to cooperate.

"Season and Corrosion Cracking of Brass" was the subject of a topical

phenomenon: "Season Cracking and Splitting of Tubes and Pipes," by Dr. William Campbell, professor of metallurgy, Columbia University, New York; "The Causes and Prevention

Tentative Specifications for Babbitt Metal

1.—These specifications cover white metal bearing alloys, known commercially as babbitt metal. Twelve typical babbitt metals are specified, covering the range of alloys commercially used, and are designated as Grades Nos. 1 to 12, in accordance with their decreasing tin content as specified in Section 4.

2.—The manufacturer shall use care to have each lot of babbitt metal as uniform in quality as possible.

3.—The standard bar, unless otherwise specified, shall have the following approximate dimensions:

Top face, 1¼ inches wide, 8½ inches long.

Thickness, not over 1¼ inches.

4.—The alloys shall conform to the following requirements as to chemical composition, within the limits specified in Section 5:

Alloy, grade No.	Tin, per cent	Antimony, per cent	Lead, per cent	Copper, per cent	Iron, max., per cent	Arsenic, max., per cent
1	91	4½	0.35*	4½	0.08	0.10
2	89	7½	0.35*	3½	0.08	0.10
3	83⅓	8⅓	0.35*	8⅓	0.08	0.10
4	75	12	10	3	0.08	0.15
5	65	15	18	2	0.08	0.15
6	20	15	63½	1½	0.08	0.15
7	10	15	75	0.50*	....	0.20
8	5	15	80	0.50*	....	0.20
9	5	10	85	0.50*	....	0.20
10	2	15	83	0.50*	....	0.20
11	..	15	85	0.50*	....	0.25
12	..	10	90	0.50*	....	0.25

*Maximum.

These alloys contain neither zinc nor aluminum.

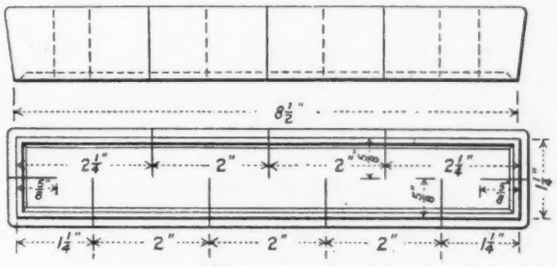


FIG. 1—METHOD OF SAMPLING

5.—The following permissible variations in the percentages of the desired elements specified in Section 4 will be allowed, but shall not apply to the maximum percentages of impurities specified:

Percentage of element specified	Permissible variations over or under the specified value, units of per cent
Not over 2 per cent	0.25
Over 2 to 5 per cent, inclusive	0.50
Over 5 to 10 per cent, inclusive	0.75
Over 10 per cent	1.00

6.—(*a*) Three bars shall be selected to represent a shipment of less than 1000 pounds, five bars to represent a shipment of over 1000 to 10,000 pounds, inclusive, and ten bars to represent a shipment of over 10,000 pounds to one carload.

(*b*) Saw cuts shall be made at points in the bars indicated in Fig. 1. No lubricants shall be used for sawing. The sawings shall be carefully treated with a magnet to remove any particles of steel introduced in taking the sample.

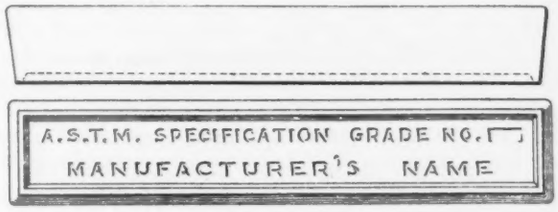


FIG. 2—PREFERRED ARRANGEMENT OF MARKING

(*c*) Sawings thoroughly mixed shall constitute the sample for chemical analysis.

7.—The chemical analysis shall be made in accordance with the tentative methods for analysis of alloys of lead, tin, antimony and copper of the American Society for Testing Materials.

8.—The name of the manufacturer shall be cast on each bar. The numerical designation of the grade supplied shall be stamped or cast on each bar for identification.

A preferred arrangement of marking is shown in Fig. 2.

9.—Claims, to be considered, shall be in writing 30 days from receipt of material at the purchaser's plant, and the result of the purchaser's test shall be given. The shipper shall, within one week of receipt of such claim, either agree to satisfy the claim or send a representative to the purchaser's plant to resample the shipment, as specified in Section 6. Samples so taken shall be sealed and submitted to a mutually agreeable umpire, whose determination shall be final.

10.—The expense of umpire analysis shall be paid by the loser, or divided in proportion to the concession made in case of a compromise. In case of rejection being established, the damages shall be limited to the payment of freight both ways by the manufacturer for the substitution of an equivalent amount of babbitt metal to meet the specifications.

Appendix

The data in Table I do not constitute a part of these specifications. They are given merely to indicate to the purchaser the physical properties of the various alloys specified which can be expected of carefully manufactured alloys of the formulas indicated, and to constitute a guide to the purchaser in selecting the grade best suited for meeting the service condition for which the babbitt metal is to be used.

Table I

PHYSICAL PROPERTIES OF WHITE METAL BEARING ALLOYS

Alloy No.	Formula— Copper, per cent	Tin, per cent	Antimony, per cent	Lead, per cent	Deformation of cylinder 1¼ in. diameter by 2½ in. high at 70° Fahr., in At 1000 lb.	At 5000 lb.	At 10,000 lb.	Brinell hardness At 70° Fahr.	At 212° Fahr.	Melting point Deg. Fahr.	Deg. Cent.	Complete liquation point Deg. Fahr.	Deg. Cent.	Specific gravity	—Weight— Oz. per cu. in.	Grams per cu. in.	Proper pouring temperature, deg. Fahr.
1	4.5	91.0	4.5	....	0.0000	0.0010	0.0150	28.6	12.8	453.2	234	699.8	371	7.34	4.24	120.28	824
2	3.5	89.0	7.5	....	0.0000	0.0015	0.0120	28.3	12.7	460.4	238	683.6	362	7.39	4.27	121.10	808
3	8.33⅓	83.33⅓	8.33⅓	....	0.0010	0.0045	0.0070	34.4	15.7	462.2	239	791.6	422	7.46	4.31	122.25	916
4	3.0	75.0	12.0	10.0	0.0005	0.0025	0.0090	29.6	12.8	365.0	185	555.8	291	7.52	4.35	123.23	680
5	2.0	65.0	15.0	18.0	0.0010	0.0030	0.0090	29.6	11.8	.....	...	.....	...	7.75	4.48	127.00	...
6	1.5	20.0	15.0	63.5	0.0015	0.0050	0.0180	24.3	11.1	.....	...	.....	...	9.33	5.39	152.89	...
7	...	10.0	15.0	75.0	0.0010	0.0050	0.0230	24.1	11.7	464.0	240	500.0	260	9.73	5.62	159.44	625
8	...	5.0	15.0	80.0	0.0020	0.0090	0.0620	20.9	10.3	469.4	243	500.0	260	10.04	5.80	164.52	625
9	...	5.0	10.0	85.0	0.0040	0.0120	0.0840	19.5	8.6	469.4	243	491.0	255	10.24	5.92	167.80	616
10	...	2.0	15.0	83.0	0.0010	0.0100	0.1540	17.0	8.9	471.2	244	500.0	260	10.07	5.82	165.02	625
11	...	....	15.0	85.0	0.0010	0.0100	0.1190	17.0	9.9	474.8	246	500.0	260	10.28	5.94	168.46	625
12	...	....	10.0	90.0	0.0025	0.0170	0.2850	14.3	6.4	474.8	246	509.0	265	10.67	6.17	174.85	634

of Corrosion Cracking," by W. H. Bassett, technical superintendent and metallurgist, American Brass Co., Waterbury, Conn.; "Season Cracking," by W. Reuben Webster, superintendent, Bridgeport Brass Co., Bridgeport, Conn.; "Initial Stress and Corrosion Cracking," by P. D. Merica and W. R. Woodward, assistant physicists, United States bureau of standards, Washington, D. C., and "The Prevention of Season and Corrosion Cracking of Brass Artillery Cases by Special Heat-Treatment", by W. B. Price, chief chemist and metallurgist, Scovill Mfg. Co., Waterbury, Conn.

In his discussion of season cracking, W. Reuben Webster pointed out that season cracking is due to the unequal distribution of stresses in the interior of wrought brass set up by the processes of cold working. It also has been recognized for some time that a contributing cause was some species of corrosion and he added that one of the baffling circumstances connected with this was the erratic nature of its occurrence. Also, in the manufacture of wrought brass an analogous difficulty is experienced known as fire cracking. This manifests itself by the occurrence of cracks in the metal which has been subjected to cold working when such metal is heated in the annealing furnace. This difficulty is prevented by employing an operation known as springing whereby the metal is distorted to equalize the direction of the internal stresses. This treatment has been found to be efficacious in preventing season cracking, but it was pointed out that the need of some test which would determine whether such stresses existed to a degree sufficient to cause trouble from this source has long been recognized. Mr. Webster stated that it has been proposed to employ a solution of mercurous nitrate into which samples are to be dipped. In case of the existence of internal strains this test will quickly detect them. However, some experience with this test has indicated that it is too severe.

Corrosion Cracking of Cartridge Cases

P. D. Merica and R. M. Woodward stated that corrosion cracking has been observed in the case of cartridge cases and condenser tubes. They pointed out that it is not limited in its occurrence to any form or shape of brass article, but has been known to occur in drawn, rolled, forged, spun and cast metal. Brass of a composition between 45 and 20 per cent zinc is subject to it and not only brass of these compositions, but also other metals such as nickel, silver, nickel steel, aluminum, aluminum bronze and other alloys have been similarly affected. They are of the opinion that initial stress is the primary factor in either corrosion or fire cracking and that this is due to some operation of manufacture such as heating, rolling or mechanical working that may not be applied uniformly to every portion of the article. For example, the nonuniform cooling of different portions of an article from a high temperature leaves initial stress in it and that part which cools most rapidly is left in compression while the remainder is in tension. This fact is well known by foundrymen who are obliged to take care of this difference in the rate of the shrinkage of castings by resorting to special methods. The welding or burning-in of castings or other articles also generally will produce initial stress in the cooled piece, the welded portion being in tension parallel to the surface and perpendicular to the weld.

Practical Problem Presented

The practical problem which the phenomenon of season cracking places before the metallurgist is three-fold: First, the development of methods for the determination or indication of the extent and distribution of the initial stresses. Second, the determination by those methods of the maximum safe limits of such stresses through corelation with service tests. Third, the discovery of methods of manufacture by which either the introduction of stresses may be avoided or whereby, after introduction, these stresses may be removed without detriment to the other properties of the metal and at the least expense.

Messrs. Merica and Woodward state that initial stresses may be removed or reduced to a safe value by annealing at a proper temperature or they may be removed mechanically by some process which introduces a stress at the surface of opposite sign to that already present.

Experiments now are in progress at the bureau of standards to ascertain directly what values of tensile stress may be regarded as safe for brass rods which are subjected to corrosion. After the installation of a new draw bench the bureau will be in position to extend this program to include similar service stress-corrosion tests of rods of graduated values of service initial stress. It is hoped to ascertain definitely what combinations of initial and externally applied stress are safe for brasses of different compositions and degrees of hardness and incidentally also to follow more definitely the corelation of such acceleration tests as the mercury salt solution test with service behavior tests.

W. B. Price, of the Scovill Mfg. Co., Waterbury, Conn., directed attention to tests made by Professor E. Heyn who stated that reheating at temperatures varying from 100 to 230 degrees Cent. gradually relieved the internal strains. The composition of the cold drawn brass rod subjected to this treatment was copper, 57.8 per cent; zinc, 40.8 per cent and lead, 1.35 per cent. Mr. Price reports the results of experiments made on four lots of finished 75-millimeter cartridge cases which had cracked at the mouth and base when subjected to the government test of immersion for a period of four hours in a 1.5 per cent solution of mercury-bichloride. A number of shells from each of the four lots tested were heat-treated for periods of one, two and three hours at a temperature of 260 degrees Cent. Some of the shells were removed at the end of the first, second and third hours of heat-treatment. While the physical properties were not apparently affected by this treatment, nevertheless the degree of internal strains was greatly diminished. None of the 12 cases tested after heat treatment failed in the mercuric-chloride test.

Richard Moldenke, chairman of the committee on cast iron, suggested the desirability of introducing a hardness test for this material and for the study of its behavior under superheated steam. The tentative specifications for soil pipe and fittings and for railroad malleable iron castings submitted last year, were referred to letter ballot for adoption. Last year the committee recommended as tentative that the maximum sulphur limit in light castings in the standard specifications for gray iron castings be increased from 0.08 to 0.10 per cent. This change likewise was adopted and referred to letter ballot for approval.

Titanium Bronze Co. Sold

The Titanium Alloy Mfg. Co., Niagara Falls, N. Y., has sold its entire interest in its subsidiary, the Titanium Bronze Co., to a group of Buffalo investors headed by C. A. Finnegan. The direct management of the Titanium Bronze Co. will remain in the hands of W. M. Corse, president of the American Institute of Metals, as in the past. The plant of the Bronze company also will remain in its present location for a year and possibly beyond that time. These quarters are leased from the Titanium Alloy Mfg. Co. The Titanium Alloy Mfg. Co. will continue to devote its energies to developing the use of titanium.

Interest Centers on Foundry Cost Problems

Accounting Methods Presented at Mechanical Engineers' Meeting Precipitate Wide Discussion—Distribution of Costs and Overhead are Important

COST accounting systems once tolerated are now eagerly demanded by progressive foundrymen. Mounting labor and material costs coupled with the need for accurate data upon which to base income tax returns call for an accurate knowledge of manufacturing cost per unit of product. Keen business insight and engineering knowledge must be brought to bear upon questions once thought to be limited to the realm of the certified accountant and the efficiency expert. An evidence of the vital importance of cost analysis to the modern manufacturer is found in the reception accorded a paper presented by Prof. William W. Bird, of Worcester Polytechnic institute at the June meeting of the American Society of Mechanical Engineers. An abstract of this paper on foundry cost accounting appeared in the June issue of THE FOUNDRY. Few papers delivered at this meeting occasioned the discussion which was accorded this description of the system of determining costs applied to the foundry laboratory work at the institute. B. D. Fuller, Westinghouse Electric & Mfg. Co., Cleveland, who is president of the American Foundrymen's association, dwelt on the importance of the overhead factor and its proper distribution. Robert S. Denham, consulting cost engineer, Cleveland, took issue with some of the points of Mr. Bird's paper and proposed a more extensive analysis of the formative process involved in producing castings. Robert E. Newcomb, superintendent, Deane Steam Pump works of the Worthington Pump & Machinery Corp., Holyoke, Mass., recommended the establishment of known rather than assumed figures upon which to base cost accounting systems. He suggested that the American Foundrymen's association cost accountants could render valuable service to colleges in the study of foundry costs. M. J. House, C. E. Knoeppel & Co., New York, outlined the ledger headings and divisions upon which the distribution of costs should be based. Practical applications of cost analysis formed the main points of these discussions.

Known Facts Should Form Basis of Cost System

By Robert E Newcomb

PROFESSOR BIRD is constantly endeavoring to bring the student engineer into actual working contact with the common everyday problems which are met after technical school training has been completed. As the author states, the cost system outlined is reliable as a signal system. It, however, might be well to give the student a more rudimentary knowledge of foundry cost keeping, otherwise the signals may be misleading.

Early in the paper it is stated: "It was decided that the three most important items were core labor, molding labor and pounds of castings produced, and that each of the other items of cost was a function of some one of these three independent items." Prof. Bird also says: "The general scheme is to charge an account with the amount of the purchases for that month and credit it with a fair estimate of what ought to have been used for that month's work."

It is axiomatic that in the management of any business, facts, not surmises, must form the basis for operating. It would apear that the cost system as outlined, based upon fair estimates, is not deep rooted in natural truths. Any cost system based on the assumption that the men using it are reasoning, thoughtful and analytical, is fundamentally incorrect. Most foundrymen possess these qualities to only a limited extent.

The following assertions, which I assume are the other items of cost which were found to be functions of the three independent variable items, are made in the paper:

Core materials, 30 per cent of core labor.
Molding materials, 6 per cent of molding labor.
Expense, 75 per cent of melting labor.
Melting, 30 cents per 100 pounds.

While all of the foregoing items may be functions of the core labor, molding labor and pounds of castings produced, they are at the same time variable functions and hence, basically *surmises* which cannot form an accurate basis for operating. Cost facts exist; they are real essential truths. W. O. Brace stated in an article some years ago: "Cost facts form a weapon for profit building, and to be effective should conform to certain conditions, which, if violated, will destroy much of the good that can be accomplished when properly wielded."

The cost system should strive to get the absolute facts and figures. Approximations, guesswork, estimates and speculations of any kind should be barred. At best, business is a gamble and the speculation should not be increased by encouraging anyone to guess at any part of the data required.

The object of cost accounting is to establish and fix profits. Every business man knows that the public fixes the selling price and that the producer has only one option, and that is to fix the cost, thereby establishing his profit or loss. To arrive at proper cost, I believe the following well established formula should be used:

Cost of material plus direct labor = Prime cost.
Prime cost plus direct factory expense = Factory cost.
Factory cost plus general expense = Cost to make.
Cost to make plus selling expense = Cost to make and sell.

In foundry cost accounting it is essential that the cost be built up from the following items representing the total of accumulated details:

Core labor in sum total.
Supplies in sum total.
Molding labor in sum total.
Chipping labor in sum total.
Miscellaneous labor in sum total.
Melting in sum total.
New metal in sum total.
Scrap in sum total.
Other expense in sum total.

The accumulative details should be obtained from records of the actual number of units of material used from day to day and actual number of hours of labor. The cost of material delivered during a current cost month

should not be used as a basis of establishing costs as is apparently suggested in Mr. Bird's paper, since it would not give a true cost. This is true by reason of the fact that the material entering the castings, especially in a foundry carrying a stock of iron may have been delivered at a considerable difference in price over that prevailing during the current month. This difference may make a considerable fluctuation in the selling price and this would apparently cause the foundry using this method to quote both low and high prices at the wrong time. A better method would be to average the cost of the pig iron and material in stock. This prevents fluctuation in apparent cost and selling price.

As a signal system to indicate the drift of the cost, a daily estimate may be made based as follows, assuming a specific case for illustration:

Let M = total number of men, 175
T = total melt in tons, 35
P = per cent average good castings, 70
L = average cost of labor per man-hour, $4.00
I = average cost of metal at ladle per ton of good castings, $25
S = average cost of supplies per ton of good castings, $10
m = average men per ton of good castings $= \frac{M}{TP}$ or $\frac{175}{35 \times 0.70} = 7.10$
Let A = average labor cost per ton of good castings = mL = 7.10 × 4 = $28.40
C = total cost per ton of good castings = AIS = $28.40 × 25 × 10 = $63.40

The foregoing figures are actual or based upon the previous month's accurately established costs, and from day to day are reasonably reliable signals indicating to the live foundryman the drift of the cost for the current month ,and in the respect that they are available from day to day, corrective measures may be taken to reduce greatly increasing costs before they become disastrous.

Professor Bird is to be commended for approaching and introducing the matter of foundry cost in his work at the Worcester Polytechnic institute and his desire to interest mechanical engineers in the management of this fundamental industry. It is suggested that the engineering colleges devoting time to the study of foundry costs co-operate with the authorized cost accountants of the American Foundrymen's association, thus enabling them to give their students the advantage of the best practice. Much may be gained by the application of practical experience.

Relating Expenses With Factors of Production

By M J House

NUMEROUS cost systems are in use which fully satisfy those who use them and, in many plants, statistical data of great importance are compiled, yet costs are far from dependable. For instance, I have in mind an important steel foundry where costs are calculated on an average basis, i. e., the total cost of production is divided by total tonnage produced to ascertain average cost per pound, and this average cost is used in computing cost of sales each month. This process alone is grossly misleading, especially in a steel foundry, where the percentage of defectives never can be reckoned with any degree of accuracy. Selling prices, however, are not based on the average cost. An elaborate system of differentials has been built up and for each dollar of direct labor cost over or under the average labor cost, cettain percentages are added or deducted. But even this method, with its elaborately constructed table of differentials does not produce dependable results. In any plant segregated by departments the cost of operating varies according to departments. The bases of distribution are not necessarily the same in all. The commercial expenses should be treated from an entirely different angle, as they bear no relation to either hours or value of direct labor or pounds of castings produced. Figuratively, the factory is selling materials, labor and expense to the commercial department at cost. The commercial cost is concerned with sales and administrative expenses, less a certain proportion of the latter assignable to plant expense varying in proportion to benefit derived. The sum of the remainder of administrative expense added to total sales expense constitutes the net commercial cost. This is properly prorated to cost of sales on basis of total cost to produce.

Reducing the accounting classification to a minimum, the ledger title for a gray iron foundry should consist of the following works accounts:

Materials and supplies (subdivided if desired).
Work in process.
Melting department (conversion expense).
Pattern department expense.
Core department expense.
Molding department expense (subdivided in many cases according to classes of molding).
Miscellaneous molding expense and supplies.
Cleaning and chipping department.
Power department.
Shipping and receiving department.
Floor space.
Manufacturing (or general) overhead.
Adjustment account.
Accrued wages.

In the general ledger there should also appear appropriate property and financial accounts, administrative and sales expense accounts, sales and costs of sales accounts and such other expense, revenue and reserve accounts as the nature and extent of the business may require.

Melting cost should include every item of expense incident to conversion of metals into molten form in the ladle ready to pour, including labor, floor space, fixed charges, supplies, power, water, maintenance and a proportion of manufacturing overhead. The factor to be used as divisor to ascertain average rate per pound for conversion would be either total purchased metals melted or total of all metal melted (including home scrap) according to the practice of the foundry as regards accounting for scrap in cost calculations.

In pattern, core and molding departments the rate should be determined by use of direct labor hours or the value of direct labor in each department as the divisor. Miscellaneous molding expenses and supplies should be prorated on basis of pounds of castings produced and to ascertain the cleaning department rate, the entire cost of operating the department, including a proportion of manufacturing overhead, should be divided by total direct labor hours or total value of direct labor in the molding and core departments. The total of manufacturing overhead should be divided by the total direct labor hours or the total value of direct labor in melting, pattern, core, molding and cleaning departments. Preceding the calculation of rates for these divisions, the total of the manufacturing overhead should be distributed to these departmental accounts and become a part thereof.

If the business is of sufficient magnitude, the shipping and receiving expenses should be cared for in separate accounts, the former being closed into sales expense and the latter into material expense. If the foundry is small, the entire cost should be closed monthly into manufacturing overhead. Power, machine, carpenter and blacksmith shops should carry only their individual burdens. For any work performed by these interde-

partments for other divisions of the plant, the department affected would be charged and these departments credited.

Power cost should be distributed to units benefited and cost of heat and light transferred to the floor space involved. Floor space cost should be prorated to the various departments on basis of square feet occupied.

Payrolls should be charged each month or cost period to accounts affected and accrued wages credited with the total; the latter being debited with cash paid out.

Summed up, the plan outlined is simple. Melting and departmental expense rates are predetermined and all expense is concentrated into six rates. When cost computations are made, which may be at any time a lot of castings are finished, the only factors to be dealt with to obtain shop cost are metal in castings, direct materials, direct labor, departmental rates and special costs in the form of patterns, flasks or other special rigging. A cost accounting plan should be so devised that expenses will be grouped and recorded with definite relation to the factors of production and to each other, not dumped into a common grave from which there is no resurrection.

Distribution of Overhead an Accounting Problem

By B D Fuller

THE cost system presented by Mr. Bird represents a step in the right direction and is satisfactory as an accounting guide for a foundry such as the one to which it has been applied. In my estimation it does not go deep enough to be thoroughly successful in accounting for costs in a large concern. Too little attention is paid to the question of overhead distribution which is an important factor.

Overhead in some cost systems is carried entirely as a percentage of direct labor cost; in others as a percentage added to poundage or weight. It is more equitable to use both bases, carrying one percentage on labor and another on weight. Some castings require an excess of labor for a minimum of weight, in which case the labor overhead would be the larger in the accounting, and justly so. But imagine a casting of excessive weight and a minimum amount of labor, such as a large floor plate cast in open sand. Here the weight basis of overhead would, in accounting, rightly carry the bulk of the load. Cost systems giving individual casting costs are much more valuable than those where the output is handled in bulk or weight classifications.

In his paper Mr. Bird says: "Most important items were core labor, molding labor and pounds of castings produced." Cleaning labor should be included as an important item. It varies widely in cost with the class of work handled. Again the author states, "The general scheme is to charge an account with the amount of purchase for that month." Payroll charges in this connection should not be forgotten.

It is stated that under the system described all expenses are charged to expense account. There should be subaccounts for the various classes of expense to care for these charges properly. One group cannot cover them.

Applying the Principles of Cost Engineering

By Robert S Denham

THE purpose of a cost system is supposed to be the determination of the total of expenses (cost) involved in the production of definite items of product. Since this paper does not undertake to show how such a result is to be accomplished, the author courted criticism by including the term "cost" in the title. The error, however, is common, and therefore more or less excusable, because the theories and practices of so-called cost accounting are based upon traditional methods no longer practical owing to the introduction of labor-saving machines.

Mr. Bird says: "After several years of experimental work it was decided that the three most important items were core labor, molding labor and pounds of castings produced, and that each of the other items of cost was a function of some one of these three independent items." Such a decision is purely arbitrary.

Further, Mr. Bird shows that the cost of core work consists of the wages of the coremakers plus a charge of 30 per cent for the materials required for their work. No consideration is given to the effect of expenses for housing, equipment, administration, etc., on core making. The monthly statements shown are further evidence of this omission.

Supplies and Labor

In another paragraph he states that all of the items of cost in the foundry excepting metal, melting and core work were divided into two classes: Supplies, or all the materials used in connection with molding, such as sand, facing, etc., and expense, or all charges for management, office work, power, cleaning, flasks and other overhead items. He further states that at present production credits for supplies are based on 6 per cent of the molding labor, and the expense on 75 per cent of the molding labor for the month. This factor is secured from the pay rolls, all molders being grouped for this purpose. It is evident that the term "labor" as used by Mr. Bird, means the amount of money paid out as wages. I contend that there is no relation between the element of wages and any of the other expenses of production here considered.

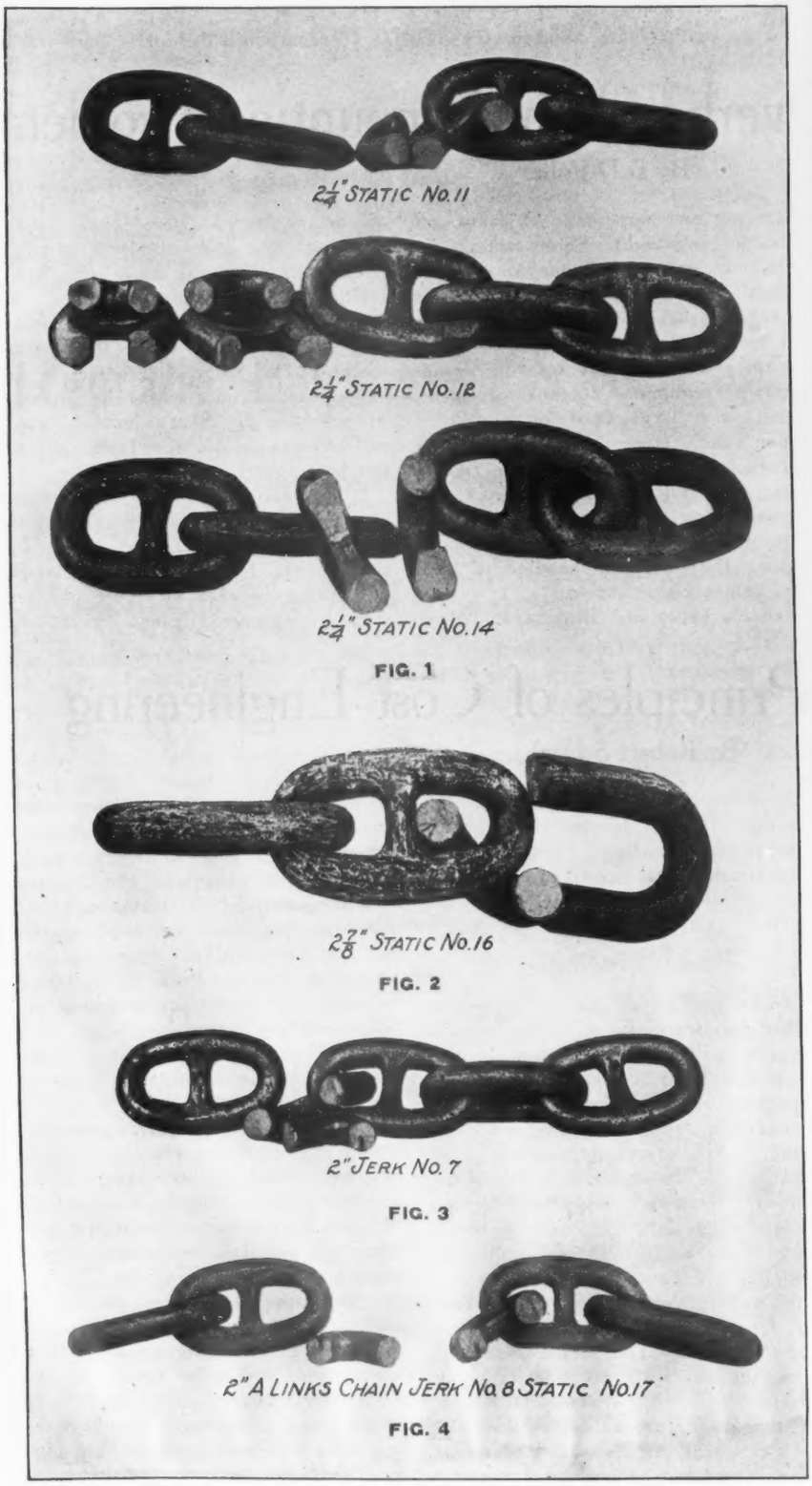
A product of whatever kind consists of materials and the time involved in the formative processes. In this paper the material is metal and the formative processes are core making, molding and melting. By analysis we find that the handling of materials or metal involves the expenses of transportation, handling labor, rent of stock yard or room, interest and insurance on investment in material, shrinkage, etc.

Analysis of the formative processes shows that each requires more or less of the following expenses: Rent, which may mean depreciation and insurance on building and interest and taxes on building and realty; heat; building repairs; depreciation; interest; insurance and taxes on equipment; power and maintenance of transmission lines; light, water, ice, soap, towels and toilet supplies; compensation insurance, replacement or losses due to spoilage; supplies required by processes; repairs to equipment; wages of workmen, foremen, helpers, watchman, and porters, etc.

(*Concluded on page* 340)

Huge Chain Cable is Now Cast Successfully

Links Are First Made Separately and Subsequently Formed Into a Chain by Casting the Connecting Links—A Double Molding Process



ANCHOR CHAINS OF VARIOUS TYPES AFTER UNDERGOING TESTS. ACCOMPANYING TABLES GIVE DETAILED RESULTS

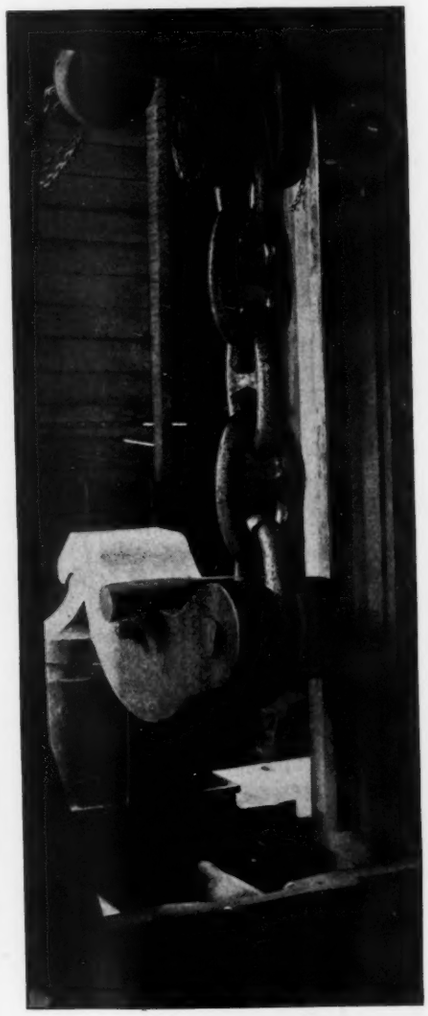


FIG. 5—DYNAMIC JERK TESTING MACHINE

ANCHOR chain must withstand severe strains and for this reason, chain cables have been forged since remote times. The war has brought about remarkable improvements in all manufacturing processes, however, and among these is a remarkable new method of manufacturing chain cable from steel castings.

This process was developed by the National Malleable Castings Co., Cleveland, after many months of research and experimental work. Exhaustive tests have been conducted recently on chains made by this process and some of the results obtained are given in this article. The chain has met with the approval of the American Bureau of Shipping and of Lloyd's.

The process employed in casting the chain is quite simple. First, one-half the required number of links are cast by methods known to every foundryman. Next, these links are again set in a mold, several at a time, spaced the

required distance apart, and the intermittent links molded and cast. This forms a complete section of chain. These sections are later cast together.

The accompanying tables and illustrations show the equipment used and the results obtained in the recent tests. In Figs. 1, 2, 4 and 10 are shown chain used in static tests. Figs. 3, 4, 7, 8, 9 and 10 show chain used in jerk tests. Detailed results are given in Tables II and III. The machine used in conducting the dynamic jerk tests is shown in Figs. 5 and 15. The method of conducting static tensile tests is illustrated in Figs. 6 and 13. Other methods developed for testing are illustrated in Figs. 11, 12 and 14. Results of a second series of tests are given in Table I.

Static and dynamic tests of the chain were made at the Sharon, Pa., plant of the National company. Government officials, and representatives of manufacturers, the American Bureau of Shipping and Lloyd's were present.

The tests were conducted on a static test machine of 1,000,000-pound capacity and on a standard master car builders drop test machine. The chains subjected to the static test were supported in the test machine by coupling each end link to the crosshead of the machine by means of a testing shackle and pin.

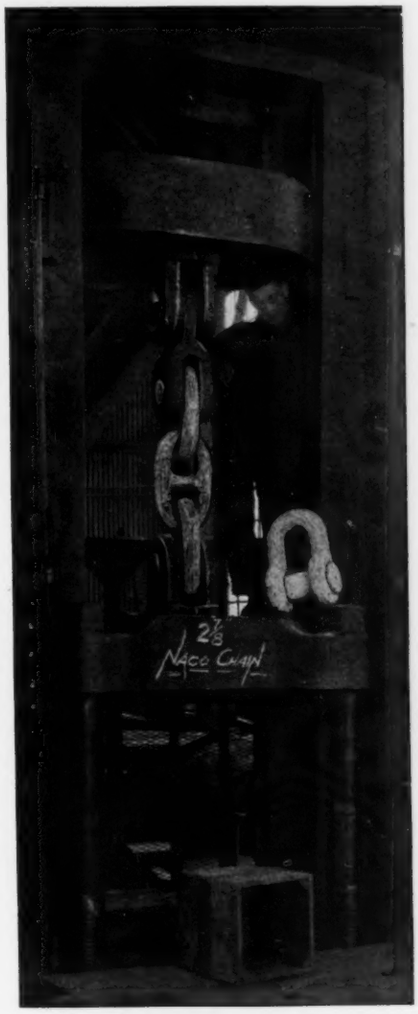
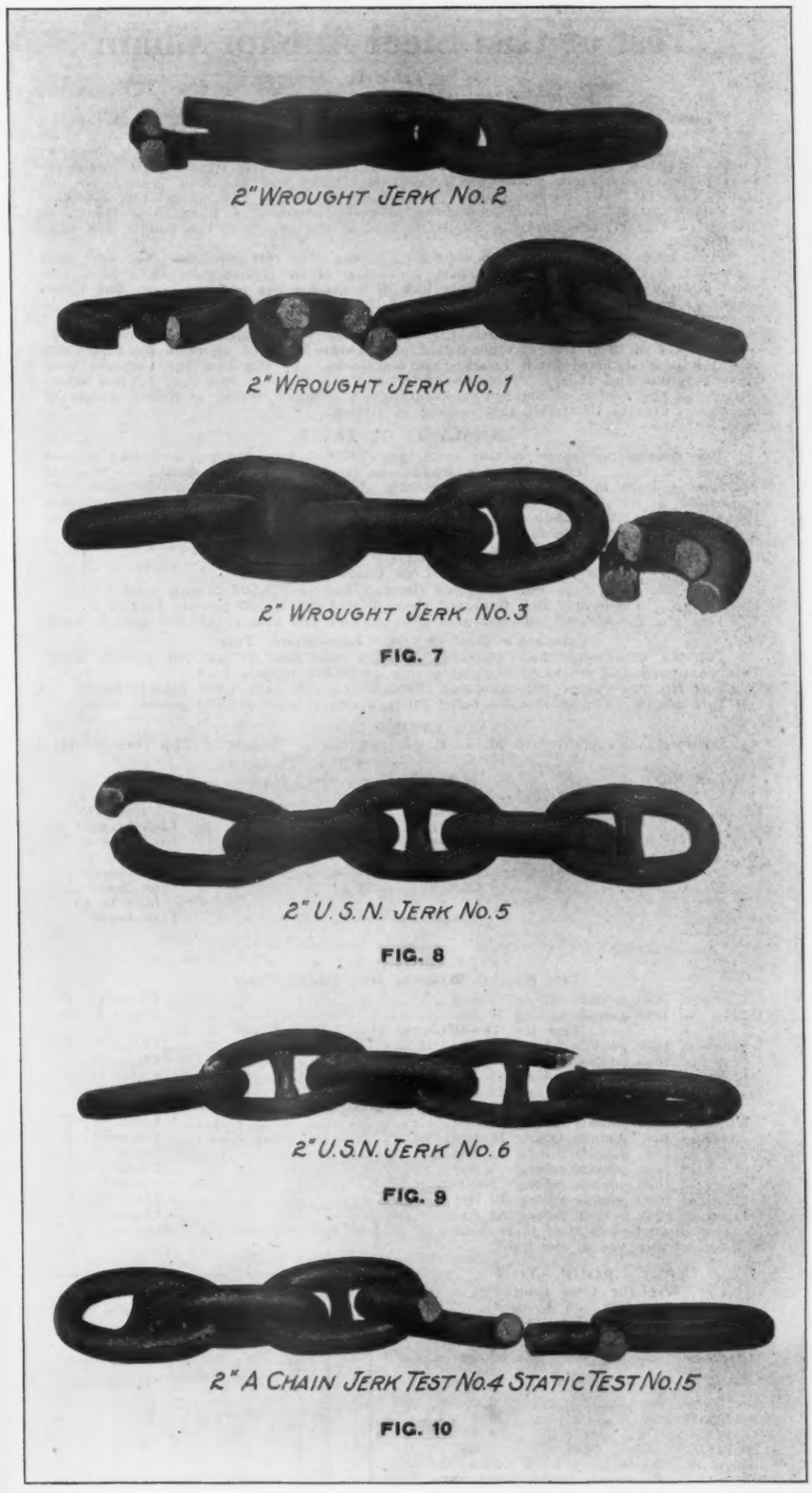


FIG. 6—MACHINE FOR CONDUCTING STATIC TENSILE TESTS


2" WROUGHT JERK NO. 2
2" WROUGHT JERK NO. 1
2" WROUGHT JERK NO. 3
FIG. 7
2" U. S. N. JERK NO. 5
FIG. 8
2" U.S.N. JERK NO. 6
FIG. 9
2" A CHAIN JERK TEST NO. 4 STATIC TEST NO. 15
FIG. 10

ANCHOR CHAINS OF VARIOUS TYPES AFTER UNDERGOING TESTS. ACCOMPANYING TABLES GIVE DETAILED RESULTS

Chains consisting of five common *A* links were subjected to a light load to reduce any possible high spots on the bearings between the links. This load was then released and a measurement over the three middle links was laid off. The elongation over this measurement was then obtained on the proof load, the breaking load and the breaking load plus 40 per cent. The first two

Test of Cast Steel Anchor Chain

Table I

METHOD OF TESTING

These tests were conducted in a static test machine of 1,000,000 pound capacity and a standard master car builders drop test machine. Two kinds of tests were made in the static machine. The first consisted of supporting separate 2-inch links on 2-inch round pins spaced 8 inches from center to center. A third 2-inch round pin was placed transversely across the link at its center and the load applied on this link. Fig. 12 shows the principle of conducting this test. The second test consisted of supporting a 2-inch chain consisting of three common *A* links in a frame, as shown in Fig. 11, and applying the static load at the center of the middle link until destruction.

Two kinds of tests were also conducted in the drop test machine. The first kind consisted of supporting a 2-inch chain consisting of five common *A* links in a vertical position by supporting the upper link in a shackle bar and the lower link in an equalizer bar, by means of shackle pins and in such manner that one half the energy developed from the falling tup will be imposed upon the chain thus suspended and in the form of a dynamic jerk. Fig. 15 illustrates this method of testing. The second kind of drop test was conducted on separate common *A* links by supporting the link in a standard MCB knuckle pin test block. In this case the supports were ¾-inch radius and 10-inch center to center and the dynamic load was applied transversely at the center of the link and through a plunger having a ¾-inch radius at its nose. Fig. 14 illustrates this method of testing.

ANALYSIS OF TESTS

For convenience these various tests are classified into groups, according to the kind of test made. Group No. 1 embodies the transverse tests conducted on separate common *A* links in the static test machine. Test group No. 2 embodies the tests conducted on the 3-link chain in the static test machine. Test group No. 3 embodies the transverse tests conducted on separate links in the drop test machine. Test group No. 4 embodies tests conducted on 5-link chains in the drop test machine.

TEST GROUP NO. 2

Wrought Iron 3-Link Chain—Static Test

Test No. 3:—Center link fractured through end at 278,500 pounds load.
Test No. 4:—Center link fractured through end at 237,500 pounds load.
Test No. 5:—Center link fractured through end and side at 230,900 pounds load.

Company's Steel—3-Link Chain—Static Test

Test No. 6:—Center link fractured through one side at 209,000 pounds load. Test continued and fractured remaining side at 93,800 pounds load.
Test No. 7:—Center link fractured through one side at 231,400 pounds load.
Test No. 8:—Center link fractured through one side at 210,000 pounds load.

TEST GROUP NO. 3

Separate link supported in M. C. B. pin test block. Weight of Tup 1640 pounds.

Test No.	Material	Fall of tup, feet	Deflection, degrees,	Remarks
9	Wrought	6	21	No fractures
10	Wrought	7	32	No fractures
11	Wrought	8	..	Link broke
12	Wrought	8	36	No fractures
13	Company's steel	8	11	No fractures
14	Company's steel	8	12	No fractures
15	Company's steel	10	*	Link broke 2nd blow at 10 ft.
16	Company's steel	12	..	Link broke

*Not measured.

TEST GROUP NO. 4

Test No. 17—Wrought Iron 5-Link Chain

3 blows of 1640 pounds falling 5 feet..... Chain O. K.
1 blow of 1640 pounds falling 10 feet..... Chain broke

Test No. 18—Wrought Iron 5-Link Chain

3 blows of 1640 pounds falling 5 feet..... Chain O. K.
3 blows of 1640 pounds falling 10 feet..... Chain O. K.
3 blows of 1640 pounds falling 15 feet..... Chain O. K.
2 blows of 1640 pounds falling 20 feet..... Chain broke

Test No. 19 Company's Steel 5-Link Chain

3 blows of 1640 pounds falling 5 feet..... Chain O. K.
3 blows of 1640 pounds falling 10 feet..... Chain O. K.
3 blows of 1640 pounds falling 15 feet..... Chain O. K.
3 blows of 1640 pounds falling 20 feet..... Chain O. K.
3 blows of 1640 pounds falling 25 feet..... Chain O. K.
3 blows of 1640 pounds falling 30 feet..... Chain O. K.
3 blows of 1640 pounds falling 35 feet..... Chain O. K.

Test discontinued after three blows at 35 feet with no apparent distortion or destruction of any one of the links.

TEST GROUP NO. 1

Wrought Iron Link
(Supported 8-inch Centers)

Test No. 1

Load, pounds	Deflection, inches
25,000	0.00
50,000	0.01
75,000	0.06
100,000	0.33
125,000	0.83
145,000	1.66

Support pins slipped from under the link at 145,000 pounds load. Total number of degrees through which link bent 53.5.

Company's Steel Link
(Supported 8-inch Centers)

Test No. 2

Load, pounds	Deflection, inches
145,000	0.00
161,000	0.01
225,000	0.17

Fractured one side of link close to stud at load of 237,300 pounds. Test continued and fractured remaining side at 145,000 pounds load. Section of metal through fracture shows solid.

loads were in accordance with specifications by Lloyd's Register of Shipping for the respective size chain. The third load is the second load increased 40 per cent. After these three loads had been applied and released and the elongation measured, a load to destruction was then applied.

Test chains consisting of two sections of *A*, *B* and *E* links shackled together with shackle *D* were tested in the same manner except that the elongation was taken over the two *B* links. The 2⅞-inch chain tested consisted of one each of the *A*, *B* and *E* links and the reading taken was over the *B* link only.

Chains tested in the drop test machine were all of the 2-inch size and consisted of five common *A* links each. These chains were installed in the test machine by connecting the upper link in a shackle bar and the lower link in the equalizer shackle by means of shackle pins passing through the eye of each link. This arrangement was such that one-half the energy of the falling tup from any given height would be dissipated in the form of a dynamic stress through all the links of the chain. The tup weighed 1640 pounds.

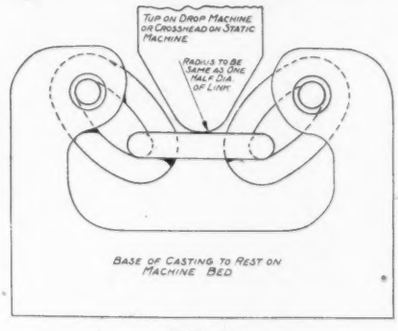

TUP ON DROP MACHINE OR CROSSHEAD ON STATIC MACHINE
RADIUS TO BE SAME AS ONE HALF DIA. OF LINK
BASE OF CASTING TO REST ON MACHINE BED

FIG. 11

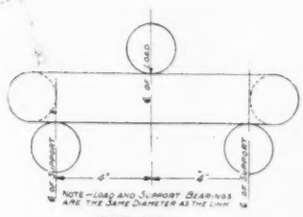


FIG. 12

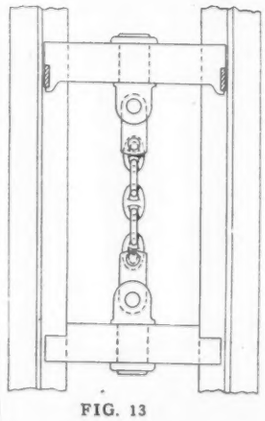


FIG. 13

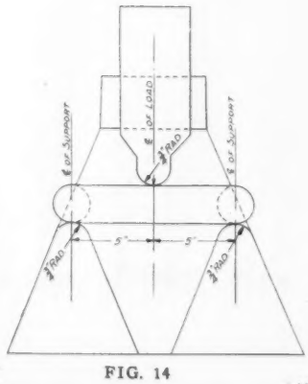


FIG. 14

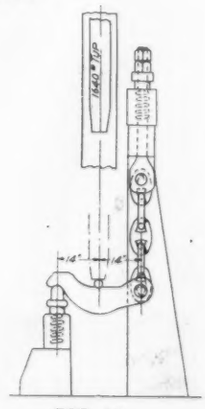


FIG. 15

Test of Cast Steel Anchor Chain

ANALYSIS OF TESTS

The following tabulations show the analysis of the tests conducted. Table III includes all static tensile tests on the various sizes of chain consisting of five common *A* links in which case the elongation was measured over the three middle links. Tests Nos. 7, 8 and 9, however, consist of two sections of *A*, *B* and *E* links connected with shackle *D*, in which case the elongation was measured over the *B* links and should thus include the elongation of two *B* links, two *E* links and shackle *D*. Table II shows the analysis of dynamic jerk tests conducted on the various kinds of chain, all of which were the 2-inch size. These chains all consist of five common *A* links and the elongation was measured as indicated over the three middle links.

Table II

Test No.	Size chain, in.	Material	—Elongation after 3 blows at, feet— 5 Inches	10 Inches	15 Inches	20 Inches	25 Inches	Total blows at 25 feet	Total blows at 30 feet	Total blows at 35 feet	Chain broke on	Total elongation, inches	Remarks
1	2	Wrought	0.02	0.05	0.15	....	....	..	..	..	1st at 20 ft.	0.15	Broke Nos. 4 and 5 links.
2	2	Wrought	0.00	0.02	....	....	....	..	..	..	2nd at 15 ft.	0.02	Broke No. 1 link.
3	2	Wrought	0.00	0.02	....	....	....	..	..	..	2nd at 15 ft.	0.02	Broke No. 1 link.
4	2	Company's steel	0.01	0.05	0.09	0.13	0.27	50	20	..	None	0.65	Chain installed in static machine. See static test No. 15.
5	2	U. S. Navy	0.10	0.34	0.68	1.37	2.21	6	..	..	6th at 25 ft.	....	Broke No. 1 link through weld.
6	2	U. S. Navy	0.06	0.32	0.74	1.32	2.08	10	2	..	None	3.85	Surface fractures in all links. Chain installed in static machine and broke No. 2 at about 241,000 pounds.
7	2	Company's steel	0.02	0.02	0.03	0.05	0.10	10	1	..	1st at 30 ft.	0.24	Broke No. 4 link. Section shows solid.
8	2	Company's steel	0.08	0.10	0.15	0.19	0.26	10	10	10	None	0.72	Chain installed in static machine. See static test No. 17.

Relative to the analysis in Tables III and II, a few interesting features in connection with these tests follow:

TABLE II, TEST NO. 4

This chain was subjected to:

3 blows at..... 5 feet
3 blows at..... 10 feet
3 blows at..... 15 feet
3 blows at..... 20 feet
50 blows at..... 25 feet
20 blows at..... 30 feet

At the completion of this test, the elongation over three links measured 0.65 inch. The test was then discontinued in the drop test machine and the chain installed in the static test machine and subjected to the proof test, breaking test and breaking test plus 40 per cent and was then loaded to destruction, during which No. 2 link broke at 452,700 pounds. The sections through the fracture show solid metal. This test is also No. 15 in Table III.

TABLE II, TEST NO. 8

This chain was subjected to a test of:

3 blows at..... 5 feet
3 blows at..... 10 feet
3 blows at..... 15 feet
3 blows at..... 20 feet
10 blows at..... 25 feet
10 blows at..... 30 feet
10 blows at..... 35 feet

The elongation over three links after this test was 0.72 inch. The test was then discontinued in the drop test machine and the chain installed in the static machine. The proof load, the breaking load and the breaking load plus 40 per cent were applied and released and the chain was then tested to destruction, during which No. 3 link broke at 467,400 pounds. The section through the fracture shows solid metal, having a small shrinkage on one side. This test is also No. 17 in Table III.

TABLE III, TEST NOS. 13 AND 14

These tests were made for the purpose of observing the effect of certain defects in steel chain. In each of these chains No. 3 link was defective on account of a shrinkage on one side of the link and in alignment with the stud. In test No. 13, the defective link broke through the defect at 502,400 pounds. In test No. 14, No. 5 link broke at 491,900 pounds, section solid. The remaining four links were again installed in the machine and loaded to destruction, during which No. 3 link broke through the defect at 502,200 pounds. While neither of the above chains was suitable for commercial purposes, it is interesting to note the slight effect of the defects.

Table III

Test No.	Size, in.	Material	Wt. of test chain, lbs.	—Elongation after— Proof load, in.	Breaking load, in.	Breaking load plus 40% in.	Chain broke at, lbs.	Remarks
1	1⅜	Company's steel	40	0.03	0.04	0.08	213,600	Broke No. 3 link. Section of metal solid.
2	1⅜	Company's steel	40	0.03	0.04	0.07	198,700	Broke No. 3 link. Section of metal few small blow holes.
3	1⅜	Company's steel	40	0.02	0.04	0.09	180,700	Broke No. 3 link. Section of metal honey-combed.
4	2	Company's steel	123	0.03	0.06	0.13	456,400	Broke No. 4 link. Small shrinkage in each fracture.
5	2	Company's steel	122	0.03	0.06	0.09	400,000	Broke No. 3 link. Section shows solid.
6	2	Company's steel	122	0.03	0.05	0.10	403,000	Broke No. 4 link. Section shows solid.
7	2	Company's steel	225	0.20	0.27	0.45	381,900	Broke top *E* link. Section shows few small blow holes.
8	2	Company's steel	223	0.10	0.22	0.63	346,500	Broke bottom *E* link. Section shows few small blow holes.
9	2	Company's steel	223	0.07	0.14	*	316,100	Broke bottom *E* link. Section shows few small blow holes.
10	2¼	Company's steel	174	0.05	0.09	0.20	494,400	Broke No. 1 link. Section shows solid.
11	2¼	Company's steel	174	0.07	0.13	0.33	495,400	Broke No. 3 link. Section shows solid.
12	2¼	Company's steel	175	0.06	0.11	0.22	513,200	Broke No. 5 link. Section shows solid.
13	2¼	Company's steel	172	0.02	0.05	0.14	502,400	Broke No. 3 link. Fractured through defect.
14	2¼	Company's steel	171	0.03	0.07	0.16	491,900	Broke No. 5 link. No. 3 link defective.
15	2	Company's steel	..	0.65	0.65	0.67	452,700	Broke No. 2 link. Section shows solid. See also jerk test No. 4.
16	2⅞	Company's steel	251	0.00	0.00	0.00	764,700	Broke *E* link. Section shows few blow holes in one side.
17	2	Company's steel	..	0.72	0.73	0.74	467,400	Broke No. 3 link. Section shows small shrinkage one side. See also jerk test No. 8.

*Not obtained.

Melting Brass in a Rocking Electric Furnace

A Marvelous Development of Great Value to the Nonferrous Casting Industry, Resulting from Experiments Conducted Under the Supervision of the Bureau of Mines

By H W Gillett and A E Rhoads

IT seems inevitable that the next few years will witness the widespread introduction of electric furnaces in the brass industry. Electric melting in a suitable type of furnace decreases the loss of metal by oxidation and by volatilization, prevents the taking up of sulphur from the fuel, gives better and more healthful working conditions, and has many minor advantages over other processes.

However, not every type of electric furnace can be used for brass melting. If brass did not differ materially from steel in its behavior during melting, electric furnaces long ago would have superseded other furnaces in nonferrous metal melting. But brass is made up of copper and zinc, and zinc is volatile at brass melting temperatures. For this reason, fuel-fired furnaces of the reverberatory type can be applied to brass only at the expense of a zinc loss so high as to prohibit the procedure. Similarly, the direct arc type of electric furnace used for steel melting, such as the Heroult, can be used only on bronzes practically free from zinc, because of the high local temperature of the melt under the arc. Indirect arc furnaces, such as the Rennerfelt, can be used on brasses carrying up to about 20 per cent zinc, but are not suitable for ordinary yellow brass on account of the formation of a superheated layer on the surface of the melt, directly under the arc, and the resulting votalization of zinc. Induction furnaces of the ordinary horizontal ring type, like the Rochling Rodenhausen, cannot be used on brass or bronze because of the high electrical conductivity of these alloys which requires a secondary current so high that the *pinch effect* causes rupture of the secondary ring. Hence it has been necessary to develop types of furnace radically different from those in use for steel in order to meet the requirements of brass.

However, two types of steel furnaces have been applied to brass (using the term brass loosely to include bronze, red brass, etc.), the Snyder, a single-phase direct arc furnace, and the Rennerfelt, a two-phase indirect arc furnace. At the Chicago Bearing Metal Co., Chicago, two 1-ton Snyder and two 1-ton Rennerfelt furnaces are melting bronze for railroad bearings, high in lead, but practically free from zinc. The metal losses are not much reduced from previous practice in crucibles and open-flame oil furnaces, but the furnaces are effecting economies in melting cost under present conditions.

The Philadelphia mint is melting nickel and coinage bronze in a 1000-pound Rennerfelt furnace. The Gerline Brass Foundry Co., Kalamazoo, Mich., melts monell metal, red brass and brass containing up to about 20 per cent zinc in an 800-pound Rennerfelt. The furnace at the Gerline plant is run on a 9-hour basis, while the other furnaces mentioned operate 18 to 24 hours a day.

Two other types of furnace designed especially for brass melting, have also found commercial use, namely the Baily and the Ajax-Wyatt. The Baily furnace uses a single-phase granular resistor, the heat from which is reflected down onto the hearth from the roof. It takes charges of about 1000 pounds. Baily furnaces are installed at the Lumen Bearing Co., Buffalo; Hays Mfg. Co., Erie, Pa.; Bridgeport Brass Co., Bridgeport, Conn., and the Baltimore Copper Smelting & Rolling Co., Baltimore. The Baily furnace is applicable to alloys of any zinc content, reduces metal losses and gives good working conditions. The main drawback of this type of furnace is that the source of heat is not close to the melt and the heat must be reflected down from the roof. In order not to overheat the roof and cause its prompt failure, as well as to hold the resistor temperature within the limits that allow reasonable life of the resistor trough, the rate of power input is low compared to the size of the furnace and weight of charge. Hence the radiation losses from walls and roof form a large proportion of the total power. The furnace is at its best on 24-hour operation. When 10-hour operation is necessary, it is found that the furnace must be heated empty during all or part of the night in order to give satisfactory output in the daytime. Because of the high heat storage in the walls, a furnace of this type does not respond promptly to

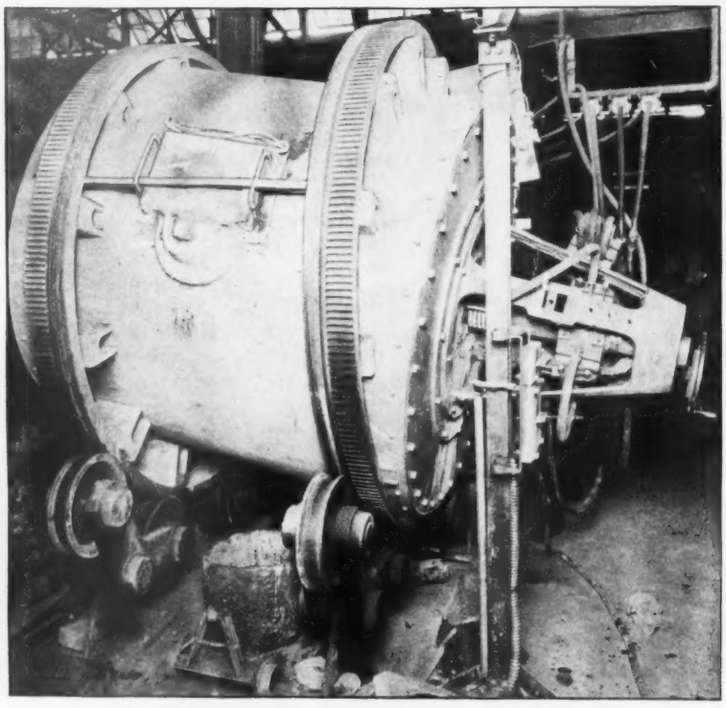


FIG. 1—REVOLVING ELECTRIC BRASS FURNACE, INCLINED TOWARD THE RIGHT TO EFFECT THE ROCKING OF THE CHARGE. THIS VIEW SHOWS THE TAPPING SPOUT

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changes in power input, and accurate control of the temperature of the melt is difficult.

The Ajax-Wyatt is a single-phase induction furnace in which the secondary ring is in the form of a loop below the level of the hearth proper, so that the hydraulic head of the metal in the hearth opposes the rupturing effect of the *pinch* force, thus avoiding the trouble that make horizontal-ring induction furnaces inapplicable to brass.

The metal heated on the secondary loop is constantly ejected at one part of each opening from loop to hearth, and colder molten metal is drawn in at another part of the opening. These fountains of hot metal issuing from the resistor melt the charge in the hearth. The constant circulation of metal is a desirable feature and gives a product of remarkably uniform chemical composition.

Because of the compactness of the furnace, the generation of heat within the metal itself, and the stirring action, vertical-ring-induction furnaces are extremely efficient as regard power consumption. The power factor in the sizes so far built is satisfactory.

The furnace must be started with a charge of previously melted metal, and sufficient metal to fill the loop must be retained when pouring. The metal in the loop must never be allowed to solidify, or the lining will be ruined. These facts make it difficult to change from one alloy to another, and require that the furnace be run 24 hours a day, or receive enough power at night to keep the fluid metal in the loop. Ramming-up and drying the refractory lining of the loop is a job requiring care and experience, as the lining must be perfect or its life will be short. No lining has yet been found that will withstand alloys containing over 3 per cent lead, and the furnace has been developed mainly for yellow brass.

The furnace is adapted for rolling mill use, where 24-hour operation on yellow brass is the rule, but is distinctly less suitable for 10-hour runs or for foundries making a variety of alloys.

Several of these furnaces are in use at the plant of the Ajax Metal Co., Philadelphia; two at the American Brass Co., Waterbury, Conn., and 28 at the Bridgeport Brass Co., Bridgeport, Conn. The furnace saves zinc and shows so low a power consumption on 24-hour operation that it can doubtless be used to advantage in rolling mill practice even under normal prices of fuel and crucibles.

Besides the four types of furnaces mentioned, each of which has found commercial use where conditions were suitable, there are four other furnaces that have reached a semicommercial stage, but are still under experimental development.

The Bennett furnace at the Scovill Mfg. Co., Waterbury, Conn., is a three-phase furnace, probably of about 750 pounds capacity, and resembles a direct arc furnace. However, the voltage between electrodes which are automatically regulated, and bath is kept so low that there is not true arc and the heat is generated by a kind of a contact resistance. This is said to give low metal losses and to show a reasonably low consumption of power. The furnace has run mainly on yellow brass and, therefore, probably is applicable to all brasses and bronzes. The results of the work have so far been kept secret and no detailed data are available to judge the merit of the process.

The Foley is a single-phase, vertical ring induction furnace, similar in general design to the Ajax-Wyatt, although differing from it in many features. One furnace of about 1000 pounds capacity has been in experimental operation at the Bristol Brass Co.'s plant, Bristol, Conn., and three 3000-pound furnaces are under construction. From the small amount of data so far available, its metal losses and power consumption will be about the same as in the Ajax-Wyatt, but because of its larger size its power factor is somewhat lower. It has the same disadvantages as regards starting the furnace, changing from one alloy to another, and the necessity for 24-hour operation, as the Ajax-Wyatt.

The General Electric is a smothered

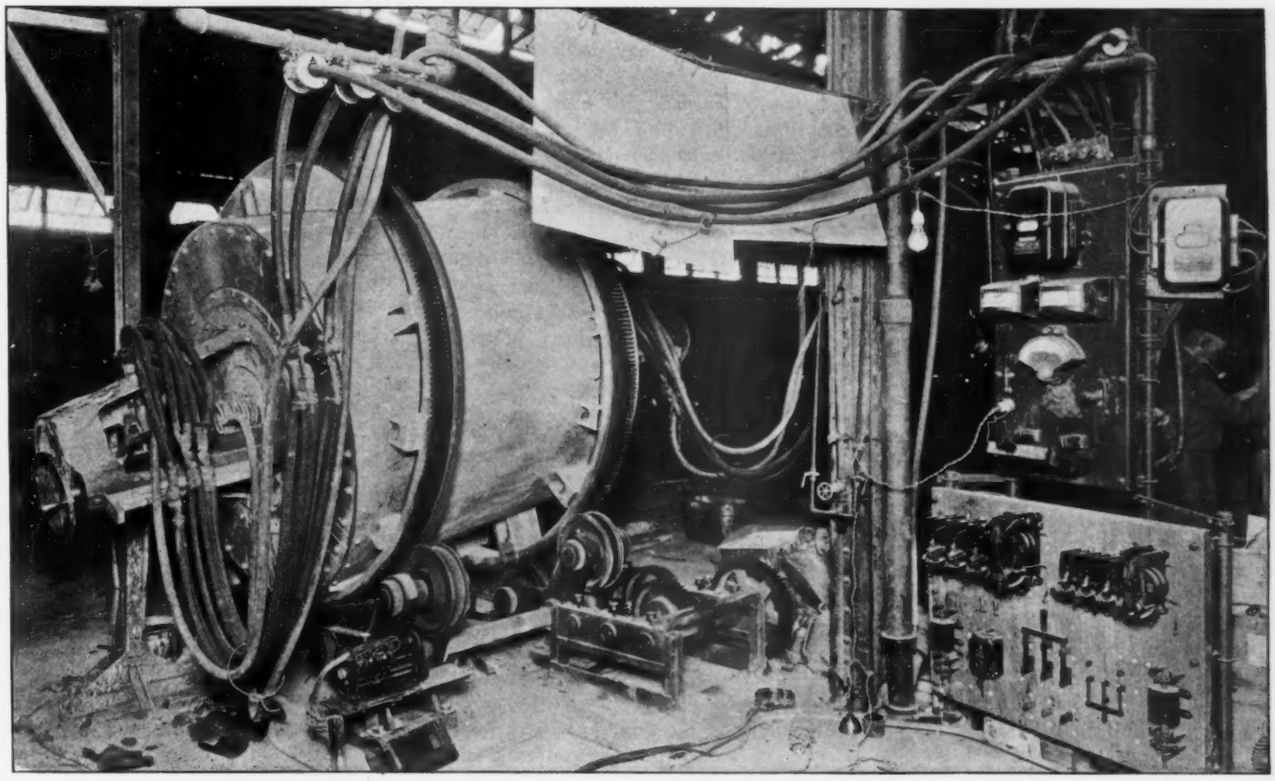


FIG. 2—END VIEW OF REVOLVING ELECTRIC BRASS FURNACE, SHOWING THE SLACK IN THE ELECTRICAL LEADS TO COMPENSATE FOR THE REVOLVING, ROCKING MOTION

arc, one or two, normally two-phase furnace, of about 1500 pounds capacity, having four depending electrodes, two on each side of the hearth. Between the tips of each pair of electrodes is a carbon block to which arcs are drawn, the arcs being smothered by granular coke. The heat thus generated is reflected down onto the hearth by the roof. The electrodes are automatically regulated.

After being tested by the General Electric Co., Schenectady, N. Y., this furnace has been installed for further test at the Chicago plant of the Crane Co., but is not yet considered ready for general commercial use.

The heat transfer in this type is similar to that in the Baily, and the furnace seems theoretically capable of a performance of about the same order as the Baily with similar advantages and similar drawbacks. As the General Electric furnace takes a higher power input than the Baily, it may be slightly more efficient in power consumption, but the roof is subject to even more severe conditions and will require the use of high grade refractories to give good life.

The Northrup, being developed by Prof. E. F. Northrup and the Ajax Metal Co., is an induction furnace, heating the charge by means of eddy currents instead of making the charge or part of it, the secondary of a transformer. Oscillating current of very high frequency is used instead of alternating, and is obtained by the use of condensers or of a special generator. A 60-kilowatt tapping type furnace is being tried out. The Northrup furnace has a high power factor and can take multiphase current. It is being developed in order to produce a furnace suitable for 10-hour operation and for facility in changing from one alloy to another.

Since the heat is generated within the charge itself, the eddy current should be efficient in power consumption. This type is theoretically very promising, but its development has not yet gone far enough to show what, if any, mechanical limitations the type will have.

Other Types Tried

Many other types of furnaces have been suggested for brass melting and a number have been tried out more or less thoroughly, but those mentioned are the most prominent of the types in commercial use or under commercial development. Most of these are either limited in their application, or have some drawbacks, either inherent in the type of furnace, or not yet eliminated by long experience in their design and use, so that no one type or make of furnace is as yet definitely proven the best for any particular set of conditions, and still less will any one furnace meet all the different conditions found in the whole range of the brass and bronze industry.

In particular, none of these types seems quite fitted to that common set of conditions where a furnace may be called upon to melt successive heats of alloys differing widely in composition, to handle both alloys free from zinc and those high in zinc, and to operate cheaply on a 9 or 10-hour day.

Rocking Electric Brass Furnace

In its study of electric brass melting during the past five years, the bureau of mines has tried out a rocking type of furnace, which may perhaps help to fill this gap. In the ordinary indirect arc type of furnace, the heat is applied above the melt and as hot metal is lighter than colder metal, there is little circulation in the bath. If the rate of heat input is at all rapid, as is necessary for thermal efficiency, heat conduction from the top of the melt downward does not keep pace with the heat supply. Before the melt, as a whole, reaches the proper pouring temperature, the surface is much superheated.

On an alloy high in zinc the surface will reach the boiling point of the zinc in that particular alloy while the bottom is scarcely melted. Such heating creates a high pressure of zinc vapor within the furnace, so that if the furnace is not tightly closed, zinc is lost continually. If the furnace is sealed tight, the pressure may even blow out the roof or door. In case the furnace holds tight and the pressure is not relieved till the spout is opened for pouring, a long hissing stream of zinc vapor then shoots out, burning in the air. This local overheating is the cause of the failure of the indirect arc furnace to handle alloys high in zinc without large metal losses.

The obvious way to overcome this trouble is to stir the melt so vigorously that the temperature of the melt is practically uniform and the superheating of the surface prevented. The most practical way to stir the melt is by the principle of the cement mixer, by turning the furnace bodily so as to stir the contents thoroughly while being heated. Constant rotation of a cylindrical furnace placed more or less horizontally, but preferably at a slight angle with the horizontal to produce endwise motion of the melt during rotation, with electrodes entering at the ends of the drum and an arc struck between the electrodes, should not only stir the charge thoroughly, avoid surface overheating and thus prevent zinc losses, but should also give a well-mixed alloy. By washing the walls with metal the heat stored in the walls and roof should be largely taken up in the metal instead of passing out. The power consumption, therefore, should be low. As the walls are washed with metal, their temperature can rise little above the temperature of the metal, which should give a good life of lining.

Instead of rotating the furnace through a complete revolution which would involve difficulty in keeping the metal out of the joints between the door and the door opening, as this opening should be on the circumference of the drum rather than on the end, and in making brush contacts to the electrodes, it appears simpler to rock the furnace back and forth so that the molten charge just fails to reach the door at either end of its rocking angle.

A small furnace of this type was built and tried out. This was rocked back and forth by hand on tracks. It was cheaply constructed from materials at hand in the laboratory and was not expected to give very good results on power consumption, as the drum was too small to allow as thick refractory lining to be of desirable thickness.

The laboratory furnace held about 100 pounds of charge, and operated on 50 to 75 volts, 500 to 700 amperes at a power factor of 85 to 90. The usual power input was about 30 kilowatts. Graphite electrodes, 2 inches in diameter were used.

Different Alloys Melted

A number of different alloys were melted in the rocking furnace. In melting 1092.1 pounds of yellow brass, made up of 45 per cent ingot, 55 per cent copper and zinc, the calculated analysis being 65.6 per cent copper and 34.4 per cent zinc, 1080.4 pounds of ingots were obtained. These analyzed 65.9 per cent copper and 34.1 per cent zinc. The metal loss by weight was 1.06 per cent which includes both volatilization and mechanical loss by spatter in pouring. The average pouring temperature was 1080 degrees Cent.

On manganese bronze chips, 40 per cent zinc, the furnace gave a net metal loss of 3 per cent. Yellow brass chips, 25 per cent zinc, gave 1.6 per cent net loss and red brass chips, 10 per cent zinc, 1 per cent.

A fine concentrate, 20 mesh, from brass furnace ashes obtained in the manufacture of an alloy of 80 per cent copper and 20 per cent zinc brass, which analyzed 71 per cent and 14.3 per cent zinc, the balance being ash, etc., after melting in the furnace.

99 per cent of the copper and 50 per cent of the zinc in the concentrate were recovered. This material is usually sent to the smelter and refined in a reverberatory furnace, not all of the copper and none of the zinc being recovered.

Yellow brass ingot, 25 per cent zinc, was remelted with 0.5 per cent loss. Red brass, 10 per cent zinc, made up from red gates, scrap copper, yellow chips, lead and tin, was melted with 0.5 per cent loss. Heavy German silver scrap, 18 per cent nickel, 56 per cent copper and 26 per cent zinc, was melted with 1.2 per cent loss. Sound copper castings were made from metal melted in the furnace.

Economy in Time and Power

Red brass containing 81½ per cent copper, 8½ per cent zinc, 6 per cent lead and 4 per cent tin, made up from red and yellow ingot and scrap copper, was melted in one series of tests with the results given in Table I, the furnace having been cold at the start.

The total elapsed time for the five heats, including charging and pouring, was five hours; 630.9 pounds of ingots were poured and 7.45 pounds metal from spillings, etc., were recovered, giving a gross metal loss of 1.35 per cent and a net loss of 0.2 per cent.

The power consumption, at the rate of 430 kilowatt-hours per ton on a five-hour run, starting from the cold, and at the rate of 295 kilowatt-hours per ton when the furnace is hot, with the metal heated to 1200 degrees Cent. is surprisingly low for so small a furnace.

The results show that the rocking furnace is a type capable of giving low metal loss and low power consumption. When the furnace was not rocked while melting alloys high in zinc, pressure built-up within the furnace and zinc losses were high. The laboratory tests having demonstrated the probable usefulness of the type, a furnace of commercial size was designed.

The Detroit Edison Co. had long been interested in electric brass furnaces as a possible outlet for electric power, and offered to co-operate by constructing a rocking furnace for commercial test without expense to the bureau of mines, except for the salaries and expenses of its representatives while supervising the test. Sketches of the furnace design were given the Detroit Edison Co., which refined the design, made the working drawings, constructed and erected the furnace.

The furnace is shown in Figs. 1 and 2. The drum is 5 feet in diameter by 5 feet long. The lining is 12 inches thick and consists of Silocel brick on the outside, special heat-insulating brick in the middle layer and corundite brick (a very refractory fire brick high in Al_2O_3) in the actual hearth lining. The hearth is 3 feet long by 3 feet in diameter, taking charges of 1300 pounds and upwards. The graphite electrodes are 4 inches in diameter, threaded for continuous feed, and are adjusted by screw-operated supports of the lathe-slide type. Single-phase, 60-cycle current, stepped down to 120 or 130 volts is used, 300 kilovolt amperes being available. Electrode adjustment is by hand, and, to stabilize the arc an external reactance is used which brings the power factor of furnace plus reactance measured at the furnace switchboard, to about 85. The open circuit voltage falls to about 106 to 116 volts under load. The current varies between 1000 and 2000 amperes, 1650 amperes being about the average. The power input can be varied by alternating the length of the arc and runs from 100 to 200 kilowatts, averaging about 165.

The flexible leads and the water hose for electrode coating are given slack to allow rocking the furnace, as is clearly shown in Fig. 2.

Rocking is Automatic

The rocking of the furnace during melting is automatically done by means of the control device shown, with cover removed, in the lower left-hand corner of Fig. 2. This can be set to give a *safe rock* of 80 degrees, the limit of motion being such that the metal just does not run into the spout. After the charge has begun to melt, the *safe rock* is started. It is called the *safe rock* because the angle is such that the solid charge will not fall on the electrodes and break them. A complete oscillation on *safe rock* takes 13½ seconds. During the safe rock the solid metal is washed about in the molten part of the charge and is tumbled over, so that fresh surfaces receive direct radiation from the arc.

As melting goes on, the rocking angle is increased by turning the handle of the control device from time to time, until, when the metal is all melted, the furnace is on the full rock of about 200 degrees. On full rock the metal washes the whole circumference of the hearth except the height of the charging door and a

Table II

COMPARATIVE METAL LOSSES IN THE ELECTRIC FURNACE AND IN COKE FIRES

Composition						
Copper, per cent	Tin, per cent	Lead, per cent	Zinc, per cent	Weight charged, pounds	Per cent loss, metal, oil and dirt coke fires	Per cent loss, metal, oil and dirt, electric
85	5	5	5	6,576	4.6	3.2
84	7	8	1	11,600	7.0	3.7
84	6	10	0	14,300	2.4	1.8
79	9	10	2	11,790	3.6	2.1
78	2	10	10	15,840	7.1	3.1
76	8	13	3	11,805	4.0	2.4
73	4	20	3	14,392	3.7	2.9
67½	4	26½	2	5,224	3.0	2.4
67	1	2	30	7,200	8.0	5.1

Table III

THE ANALYSES OF THE MIXTURES SOUGHT AND OBTAINED BY THE ELECTRIC FURNACE SHOWED LITTLE DIFFERENCE

	Copper, per cent	Tin, per cent	Lead, per cent	Zinc, per cent
Sought	76.0	8.0	13.0	3.0
Electric	75.9	8.3	13.1	2.7
Sought	76.0	8.0	13.0	3.0
Electric	76.2	8.0	12.4	3.2
Sought	85.0	5.0	5.0	5.0
Electric	85.2	4.9	4.8	5.0
Sought	83.0	4.0	6.0	7.0
Electric	82.9	4.4	5.7	6.9
Sought	67.0	1.0	2.0	30.0
Electric	66.6	1.0	2.0	30.4
Coke	68.4	0.5	1.7	29.3
Sought	68.0	1.0	7.0	24.0
Electric	67.9	...	...	....
Coke	69.9	...	...	....

Table I

RESULTS OF MELTING RED BRASS, FURNACE HAVING BEEN COLD AT THE START

Heat No.	Weight of charge, pounds	Time arc was on, minutes	Pouring temp., degrees, Cent.	K. W. H. used	K. W. H. per 100 pounds
L34	127.3	57	1140	40	30¼
L35	127.75	50	1180	30½	25
L36	128.5	50	1220	26½	20½
L37	126.5	37	1220	22½	17¾
L38	129.5	36	1220	19	14¾
	*639.55	†46	*1200	*138½	†21¾

*Total. †Average.

few inches above and below it, so that metal does not splash into the door joint. A complete oscillation takes 33½ seconds.

The reversal of the 5-horsepower motor at either end of the rocking angle is done by contactors, operated by solenoids actuated by the contacts on the control device. When it is desired to depress the spout past the limiting point of the automatic rock for pouring, the control device is switched out and the solenoids are operated by a reversing switch.

The furnace is installed at the plant of the Michigan Smelting & Refining Co., Detroit, which makes brass ingots to customer's specifications from chips, scrap and junk of various kinds, by means of strict chemical control. As the firm makes no sand castings, but ingot only, no observations on the comparative quality of metal melted in the electric furnace and in the coke fires were possible. All the metal melted was poured into ingots which went into the regular output of the plant. As far as could be ascertained by analysis and appearance, the electrically-melted metal was of at least as good a quality as from the coke fires. On alloys high in lead there was somewhat less segregation than in the metal melted in crucibles, and on charges high in zinc, the zinc content of the metal from the electric furnace was higher than that from the same charges melted in the coke fires.

Comparing Metal Losses

As there is generally much oil on the borings and some nonmetallic material in the other scrap, the true metallic content of the charge is seldom accurately known. Hence the net metal losses cannot be exactly determined.

The metal losses, therefore, were compared with those of the coke-fired crucible furnaces operating on the same charge. From 102 tons of metal melted in strict comparison with the crucible furnaces, the rocking electric furnace produced 3626 pounds more metal from the same charge than the coke fires, or 1.8 per cent. The alloys melted ran from 90 per cent to 66 per cent copper; 1 per cent to 9 per cent tin; 1½ per cent to 26½ per cent lead and 0 to 30 per cent zinc. The comparative metal losses on a few alloys in the electric furnace and in the coke fires are given in Table II.

The rocking furnace gave alloys analyzing very close to the calculated analysis, especially if the difficulty of calculating the analysis of a scrap charge is considered. Characteristic analyses are given in Table III.

There was no difficulty in drawing the metal completely from the hearth and alloys of different composition can be made one after the other without contamination by metal left in from the previous heat.

The power consumption on 10-hour operation, with no night heating is given in Table IV, which contains a resume of five days' operation. The power consumption on 24-hour operation is given in Table V for a four-day run with copper, tin, lead and zinc.

Table IV

RESUME OF FIVE DAYS' OPERATION, 10 HOURS PER DAY, WITH NO NIGHT HEATING

Heat No.	Alloys: Copper, per cent	Tin, per cent	Lead, per cent	Zinc, per cent	Nature of chg.	Lbs. charged	Secondary: Elapsed time hrs.min.	K. W. H. arc	K. W. H. motor	Total secondary power	Pouring temp., degrees Cent.,	Weight poured lbs.	Primary K. W. H.	Secondary K. W. H./cwt. chgd.	Secondary K. W. H./cwt. poured	Primary K. W. H./cwt. chgd.	Primary K. W. H./cwt. poured	Remarks
Nov. 5:																		
192	85	5	9	1	*	1314	3:40	257	4	261	1095	....	....	20.0	....	....	....	A
193	85	5	9	1	*	1314	1:50	219	3	222	1120	....	....	17.0	....	....	....	
194	79	9	10	2	†	1304	1:35	196	2	198	1165	....	....	15.0	....	....	....	
195	79	9	10	2	†	1304	1:30	190	2	192	1205	....	....	14.5	....	....	....	
196	79	9	10	2		1304	1:40	190	3	193	1205	....	....	15.0	....	....	....	B
Day total, 5 heats						6540	10:15	1052	14	1066	1155	6360	1162	16.3	16.8	17.8	18.3	
Nov. 6:																		
197	79	9	10	2	†	1304	1:45	235	3	238	1165	....	....	18.5	....	....	....	
198	79	9	10	2	†	1304	1:30	199	3	202	1190	....	....	15.5	....	....	....	
199	79	9	10	2	†	1304	1:40	186	2	188	1230	....	....	14.5	....	....	....	
200	79	9	10	2	†	1304	1:40	176	2	178	1225	....	....	13.5	....	....	....	
201	79	9	10	2	†	1304	1:30	162	2	164	1150	....	....	12.5	....	....	....	
202	79	9	10	2	†	1304	1:45	160	2	162	1165	....	....	12.5	....	....	....	C
Day total, 6 heats						7824	9:50	1118	14	1132	1195	7571	1236	14.7	15.0	15.8	16.3	
Nov. 7:																		
203	79	9	10	2	†	1304	1:35	215	3	218	1165	....	....	17.0	....	....	....	
204	79	9	10	2	†	1304	1:40	195	2	197	1135	....	....	15.0	....	....	....	
205	79	9	10	2	†	1304	1:30	180	2	182	1190	....	....	14.0	....	....	....	
206	79	9	10	2	†	1304	1:35	173	2	175	1170	....	....	13.5	....	....	....	
207	84	6	10	0	**	1304	1:40	165	2	167	1175	....	....	13.0	....	....	....	
208	87½	5	½	7	**	1304	2:30	178	3	181	1065	....	....	14.0	....	....	....	D
Day total, 6 heats						7824	10:30	1106	14	1120	1160	7583	1210	14.4	14.8	15.6	16.0	
Nov. 8:																		
209	84	6	10	0	**	1300	3:00	246	2	248	1120	....	....	19.0	....	....	....	E
210	84	6	10	0	**	1300	1:40	198	3	201	1190	....	....	15.5	....	....	....	
211	84	6	10	0	**	1300	2:05	188	2	190	1190	....	....	14.5	....	....	....	F
212	84	6	10	0	**	1300	1:30	169	3	172	1190	....	....	13.5	....	....	....	
213	84	6	10	0	**	1300	1:50	170	1	171	1190	....	....	13.0	....	....	....	G
Day total, 5 heats						6500	10:05	971	*11	982	1175	6341	1069	15.1	15.5	16.5	16.9	
Nov. 9:																		
214	84	6	10	0	**	1300	1:45	223	4	227	1190	....	....	17.5	....	....	....	
215	84	6	10	0	**	1300	2:05	198	3	201	1205	....	....	15.5	....	....	....	
216	84	6	10	0	**	1300	1:00	195	2	197	1180	....	....	15.0	....	....	....	
217	84	6	10	0	**	1300	1:45	189	3	192	1235	....	....	14.5	....	....	....	
218	84	6	10	0	**	1300	1:25	165	2	167	1175	....	....	13.0	....	....	....	
Day total, 5 heats						6500	8:50	970	14	984	1200	6407	1073	15.2	15.4	16.5	16.7	

*Average.

†Little bulkier than average.

**Very bulky.

A—Furnace cooler than usual, not run previous two days. No. 192 includes 1 hour 20 minutes.—100 K. W. H. preheat.

B—Time includes 20 minutes charging heat 197.

C—Time includes 20 minutes charging heat 203.

D—Includes 50 minutes delay by broken electrode, broken in charging bulky charge, also 20 minutes charging heat 209.

E—Time includes 1 hour, 10 minutes delay due to broken electrode due to bulky charge. Long delay due to nipple being over-size and requiring to be filed down.

F—Includes 25 minutes adjusting electrode holder.

G—Includes 20 minutes charging No. 214.

On the basis of the power read on the high tension side of the transformer, per ton of metal poured, the power consumption on 10-hour operation was 336 kilowatt-hours per ton, on red brass poured at 1180 degrees Cent., average. For 24-hour operation, the figure is about 260 kilowatt-hours per ton, for red brass.

Electrode Consumption

The electrode consumption was 16.3 pounds while melting 21,660 pounds of metal, or 1½ pounds per ton, equivalent to about 40 cents at present electrode prices. To this must be added the loss due to accidental breakage. There were nine breakages in melting 72 tons, four of which were due to the charge being so bulky that it fell against the electrodes when rocking started, and five to the electrodes being hit while bulky material was being charged. The design of the furnace has now been altered so as to allow the electrode tips to be withdrawn into the walls during the charging of bulky material. When an electrode does break, if nipple joints are used, the breakage is usually of the nipple only.

In the 24-hour tests tabulated in Table V, and in a 10-hour run just preceding the 24-hour run, in which the 75.25 per cent copper, 7.5 per cent tin, 14.25 per cent lead and 3 per cent zinc alloy was melted, the following materials were charged:

	Pounds	Oil	Pounds, non-metallic
Ingot	25,200	... .	
Red borings	11,200	2% =	224
Medium brass	1,540	... .	
Scrap copper	10,987	... .	
Ingot copper	552	... .	
Lead	3,906	... .	
Yellow borings	1,400	3% =	42
			266

For the 86 per cent copper, 6 per cent tin and 10 per cent lead alloy there was charged:

	Pounds
Ingot	16,000
Copper	4,704
Lead	96
	20,800
Total charge	75,605
Non-metallic	266
	75,339

There was obtained.

53,841 pounds good ingot 75¼ copper, 1349 pounds gross loss or 1.8 per cent.
20,149 pounds good ingot 86 copper.

73,990 pounds good ingot.
63 pounds scrap 75¼ copper.
43 pounds scrap 66 copper.
300 pounds metallic in 569 pounds skimming from 75¼ copper;
130 pounds metallic in 246 pounds, skimming from 86 copper;
53 per cent metallic in all skimming.
365 pounds metallic in 429 pounds ladle skulls from 86-85 per cent, copper by assay.

74,891 pounds total metallic recovery — 448 pounds net loss, or 0.6 per cent.

In heats 256-313, on over 37½ tons melted, 68 pounds electrodes were used, including all broken stubs and scrap, or about 2 pounds per ton.

Table V

REPORT OF FOUR DAYS' CONTINUOUS OPERATION
(Mixture melted, follows: Copper, 75.25 per cent; tin, 7.5 per cent; lead, 14.25 per cent and zinc, 3 per cent)

April 30, 1918 Consecutive heat No.	Day heat No.	Weight of charge, lbs.	Elapsed time, hrs. min.	Melting time, hrs. min.	K. W. H. arc and rocking motor read on secondary side	Equivalent K. W. H. on primary side	Primary K. W. H. per ton charged	Remarks
261	1	1,305	2:09	1:47	229	...	...	Started 6:30 a. m. Furnace idle since 4:30 p. m., April 29.
262	2	1,305	1:53	1:25	192	....	...	
263	3	1,305	1:55	1:22	165	....	...	
264	4	1,305	1:44	1:15	152	....	...	
265	5	1,305	1:44	1:15	144	....	...	
266	6	1,305	2:12	1:02	141	....	...	Included in elapsed time are 30 minutes for adjusting electrode sections and tapping new grips.
265	7	1,305	1:30	:55	153	....	...	
268	8	1,305	1:35	:58	156	....	...	
269	9	1,305	1:41	1:00	151	....	...	
270	10	1,305	1:33	1:02	146	....	...	
271	11	1,305	1:33	:59	143	....	...	
272	12	1,305	1:47	1:06	149	....	...	
273	13	1,305	2:01	1:02	150	....	...	Eighteen minutes are included for replacing broken electrode nipple.
Day's total		16,965	23:17	15:11	2074	2270	268	End of heat at 5:40 a. m.
May 1, 1918								
274	1	1,305	2:11	1:18	143	....	...	Included is a wait of 36 minutes for helpers to pour metal.
275	2	1,305	1:49	1:12	147	....	...	
276	3	1,305	1:40	1:07	152	....	...	
277	4	1,305	1:35	:55	147	....	...	
278	5	1,305	1:45	1:12	142	....	...	
279	6	1,305	3:00	1:20	160	....	...	Included are one hour and 10 minutes for replacing broken electrode nipple and altering cooling coil.
280	7	1,305	1:32	1:02	151	....	...	
281	8	1,305	1:21	:57	146	....	...	
282	9	1,305	1:19	:53	145	....	...	
283	10	1,305	1:23	:55	151	....	...	
284	11	1,305	1:31	:56	152	....	...	
285	12	1,305	1:34	1:01	152	....	...	
286	13	1,305	1:20	:48	141	....	...	
287	14	1,305	1:35	:53	147	2292	249	
Day's total		18,770	23:35	14:29	2076	....	...	End of heat at 5:20 a. m.
May 2, 1918								
288	1	1,305	1:35	1:05	150	....	...	Heat started at 6:35 a. m. Furnace idle one hour, 25 minutes between shifts.
289	2	1,305	1:25	:52	145	....	...	
290	3	1,305	1:25	:57	143	....	...	
291	4	1,305	1:20	:55	144	....	...	
292	5	1,305	1:35	1:02	144	....	...	
293	6	1,305	1:39	:56	141	....	...	Much delay in pouring this heat, no helpers.
(Mixture changed to copper, 84 per cent; tin, 6 per cent and lead, 10 per cent								
294	7	1,300	1:31	1:04	140	....	...	
295	8	1,300	1:18	:50	158	....	...	Furnace idle 45 minutes during change of shifts between 294 and 295.
296	9	1,300	1:48	:59	158	....	...	
297	10	1,300	1:22	:52	151	....	...	
298	11	1,300	2:13	1:05	156	....	...	39 minutes included changing broken electrode.
299	12	1,300	1:28	:59	162	....	...	
300	13	1,300	1:37	1:10	179	....	...	
301	14	1,300	1:49	1:12	163	....	...	Heat ends at 5:20 a. m.
Day's total		18,230	22:05	13:59	2126	2318	254	
May 3, 1918								
302	1	1,300	1:43	1:14	167	....	...	Heat started at 6:45 a. m., furnace idle 1 hour, 35 minutes between shifts.
303	2	1,300	1:43	1:22	158	....	...	Furnace idle 1 hour between heats 302 and 303.
304	3	1,300	1:55	1:09	158	....	...	Furnace idle 1½ hours replacing broken electrode.
305	4	1,300	1:44	1:17	159	....	...	Furnace idle 25 minutes patching electrode hole.
306	5	1,300	1:50	1:16	166	....	...	
307	6	1,300	1:35	1:10	162	....	...	
308	7	1,300	1:23	1:10	162	....	...	
309	8	1,300	2:15	1:05	165	....	...	42 minutes delay included, broke two electrode nipples charging.
(Mixture changed to copper, 75.25 per cent; tin, 7.5 per cent; lead, 14.25 per cent and zinc, 3 per cent								
310	9	1,305	1:19	:55	152	....	...	
311	10	1,305	1:14	1:00	140	....	...	
312	11	1,305	1:21	:50	142	....	...	
313	12	1,305	1:36	1:13	144	....	...	Last ladle poured, 6:35 a. m.
Day's total		15,620	19:38	13:41	1875	2005	262	
4 day's total		69,085				8865	257	

Since the operation was only experimental, it is not yet possible to give exact figures on the life of a lining, but as near as can be estimated the relining cost for labor and material should be well under 50 cents per ton with a corundite lining when melting red brass poured at 1150-1200 degrees Cent. If only yellow brass poured at 1100 degrees Cent. is melted, the lining cost will be still lower. If very hot bronze is to be produced, say at 1300 degrees Cent., the roof and upper portions of the ends should be lined with zirkite brick.

Accurate temperature control is easy in the rocking furnace, since at the end of a heat, after the full rock, the walls are no hotter than the metal, and there is no heating up of the charge from hotter roof and walls when the power is shut off, as is the case of furnaces where the heat is reflected downward from the roof. After cutting off the arc, the temperature falls very slowly, about 2 to 3 degrees Cent., per minute. By running the arc a minute or so every 10 or 15 minutes, a charge can be held at pouring temperature for an indefinite period.

One man can operate the furnace, with the aid of a helper while charging. Were automatic electrode control used, which could easily be done, one man could probably attend to two furnaces.

Various modifications and improvements in design were made during the tests, and others that could not well be made on the first furnace, are being incorporated in other furnaces of this type now being built for Detroit firms. The electrodes were at first introduced into the furnace directly through the refractory walls. When making yellow brass from new materials requiring the addition of much spelter, the zinc, vaporized during the addition of the spelter of the molten charge, had a tendency to condense in the clearance between the electrode and the hole through which it entered. This would then freeze, solder the electrode in place and cause breakage. Such trouble was later obviated by the use of graphite sleeves about the electrodes and by the proper arrangement and operation of the electrode coolers. It was also found feasible to charge the zinc with the rest of the charge instead of speltering at the end of the heat.

Power Consumption Compared

From data on hand on the power consumption of other types of electric furnaces, it appears that when operated on the same alloy, heating it to the same temperature, and running the same number of hours per day, the rocking furnace is somewhat more efficient than the direct arc and unrocked indirect arc types; very much more efficient than electric furnaces of types in which heat is reflected onto the charge from the roof, and very little less so than the induction furnaces. These conclusions follow not only from the data at hand, but from the method of application of heat in the various types, those with the source of heat at a distance from the charge being less efficient than those where the heat is developed close to the charge, while the induction furnaces, with the heat developed in the charge itself, should be the most efficient. On account of the washing of the walls with the metal, the rocking furnace theoretically should come next to the induction type in thermal efficiency.

Metal Losses

In magnitude of metal losses, the rocking type gives at least as good results as any other electric furnace. The only possible loss is from the stream of metal while pouring, as the furnace is sealed tight while running. Volatilization from the stream while pouring of course, is about the same in all types of furnaces.

In close control of temperature of the melt the rocking furnace seems superior to any except the induction type. In thorough mixing of the charge, the rocking type is about on the same plane as the induction type and seems markedly superior to the other types, where, in large sizes, segregation in the bath may be a serious problem.

For example, the following shows the analysis for copper of the first ingot, the first ladle and of the last ingot from the last ladle, when melting a 1200-lb charge of 60 per cent copper, 37 per cent zinc and 3 per cent lead:

Heat	First Ingot, First Ladle Copper, per cent	Last Ingot Last Ladle Copper per cent
322	59.76	59.54
323	59.78	59.66

In ability to change from one alloy to another, it is superior to the vertical ring induction type, and in ability to operate cheaply when used but 10 hours a day, without night heating, is ahead of the vertical ring induction type and of the reflected-heat type.

It can handle alloys of any zinc or lead content, being superior on this score to the direct arc, unrocked indirect arc and induction types. The electrode cost compares favorably with other arc furnaces. With equal conditions of operation, and suitable refractories in each type, the cost of lining will probably be about the same as with most other types.

Labor cost should be about the same in all hand regulated arc furnaces. With automatic regulation, which can be applied if desired, the rocking type should show a labor cost about the same as that of any other type.

From the electrical point of view, of desirability of steady load, the rocking furnace is not so desirable as the induction or granular resistors furnaces. It does not require special transformers, which are necessary for the granular resistor type. It lacks the electrical advantages of multi-phase furnaces. In very large sizes, two arcs could be used in the rocking type, but in sizes up to one ton, single-phase operation is required, and in a plant so located that the power supply must be of a limited capacity, a single-phase arc furnace, with its fluctuating loads, may not be satisfactory from the electrical point of view. Such fluctuation is no drawback in Detroit, nor would it be in most cities or large manufacturing towns.

From the results on furnaces of 1250 and 1300 pounds capacity, it appears that the rocking type can be built in a wide range of sizes without showing a great loss of efficiency in the smaller sizes. This type doubtless can be built in as large sizes as the brass industry normally could use.

While further tests in different plants and under different conditions, which will, at least in part, be made in the near future, are needed to give accurate data on the complete performance of the rocking type of furnace, it would seem from the results so far that it may be of distinct value in the brass industry, especially under present conditions as to crucible prices and quality, fuel supply and prices, and metal prices.

At the conclusion of the tests conducted by the Bureau of Mines, which covered over 300 heats, the experimental furnace was put on regular production by the Michigan Smelting and Refining Co., which is having four 1-ton rocking furnaces built, and two are under construction for the Electro-Bronze Co., Detroit.

Free Licenses Granted

The patents taken out by the Bureau of Mines on the rocking furnace have been assigned to the Secretary of the Interior as trustee, and free licenses to operate under them can be obtained by making application through the director of the Bureau of Mines.

Grateful acknowledgement is made to Cornell University for use of the well-equipped Cornell electric furnace laboratory in the work on the laboratory furnace, to Dr. J. M. Lohr, formerly of the Bureau of Mines for aid in the work on the laboratory furnace, to the Michigan Smelting and Refining Co. for facilities for the test, and to the Detroit Edison Co. and particularly to E. L. Crosby of that company for never-failing co-operation in the work.

PROBLEMS OF THE BRASS FOUNDER

What To Do and How To Do It

Overcoming Porosity in a Bronze Piston Sleeve

Recently we have had considerable trouble from porosity in a bronze piston sleeve for a wood pulp grinder. The casting is 33 inches long, 5¾ inches in diameter and is flanged on one end. The metal is ⅜-inch thick and we pour the casting horizontally with the gate end raised about 3 inches. The flanged end is farthest from the gate and a riser is placed on the flange, the metal being flowed through. After the castings are machined the porosity is exposed, the pits sometimes being as large as blow holes. An all-scrap mixture is employed, including small valves, car brasses, etc., and this is deoxidized with 1 per cent of phosphor copper.

More attention should be given to your method of melting the metal. Add to the metal, charcoal or blocks of hardwood together with about 1 ounce of salt for each pot. Also use only 0.5 per cent of the phosphor copper in place of 1 per cent and pour on the hot side into a thoroughly vented mold. If the castings are still porous, the mixture should be changed, using 50 per cent of new metal and 50 per cent of scrap. Charge into the crucible 50 pounds of scrap valves, car brasses being eliminated. On top of this charge 42½ pounds of copper followed by the salt and the charcoal or hardwood. Melt down quickly and stir thoroughly when hot. Then add 2½ pounds of tin, 2½ pounds of zinc and 2½ pounds of lead. Stir again, after which ¼-pound of phosphor copper should be added. Before pouring, the metal should again be stirred and it should be forced into the molds. The cores should be vented with a circle of ¼-inch holes placed not more than 1 inch from the skin of the core. These holes should be connected at either end with the center vent and care must be exercised to prevent the metal from flowing into these vents.

Removing Cores From Aluminum Manifold Castings

We are making aluminum manifold castings and experience difficulty in removing the cores. We would like to have a core mixture that will be satisfactory for this work.

A hard core should never be employed for aluminum as the metal will not lay to it thereby causing defects in the castings. If an oil sand core is desired, the following mixture is recommended: Sharp sand, preferably silica, 6 pounds; new molding sand, 2 pounds and oil binder, 3 ounces. This sand is weighed when dry and then is mixed with water. The oil is weighed on the same scales as the sand and is mixed with the latter after it has been moistened. Bake the cores in a hot oven. For a mixture without oil, the following may be employed: Old molding sand, 30 parts; new molding sand, 30 parts and sharp sand, 40 parts. Mix and add one part of dextrine.

Casting Aluminum Against Iron

We are experimenting with an aluminum cylinder head inside of which is a cast iron valve, and we have difficulty in preventing the aluminum from cracking. The white metal is cast around the cast iron valve. We have tried a number of different aluminum alloys, have heated the cast iron, have flowed the metal, but the aluminum cracks.

If the cast iron has been heated red hot and if the aluminum still persists in cracking, there remains no practical method for overcoming this difficulty caused by the shrinkage of the aluminum around the cast iron. An alternative is to cast the cylinder head without the cast iron valve and to provide an opening in the aluminum casting sufficiently large to permit of centering the valve therein, leaving a space between the cylinder head and the valve into which the molten aluminum can be poured.

Removing Adhering Slag

We would like to know what will dissolve the remainder of the slag which adheres to the lining of our open-flame gas furnace. We have tried glass as a flux but without success.

To remove the slag it will be necessary to use some flux that will form an easily fusible compound with the slag, thereby removing it by melting. Fluorspar, or a mixture of fluorspar and soda ash, is recommended for this purpose. This should be charged into the furnace and melted, and when fluid the furnace should be rotated to bring the flux into contact with the adherent slag.

Bronze Mixture for Hydraulic Castings

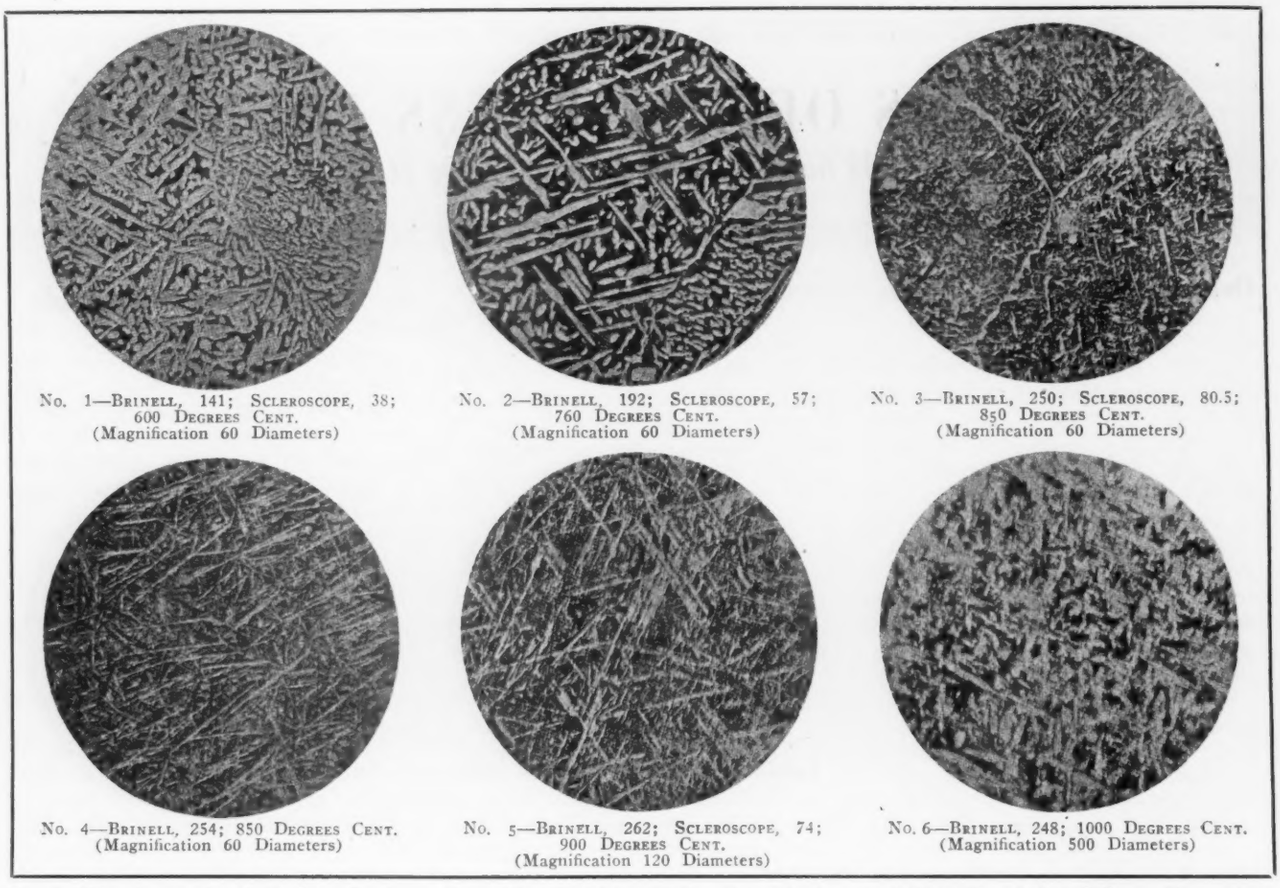
We would like to obtain a bronze mixture suitable for hydraulic castings. These are to be 5/32-inch thick and are to be subjected to a pressure of 1500 pounds. We have made some of these castings from a mixture containing copper, 86 per cent; tin, 6 per cent; zinc, 6 per cent and lead, 2 per cent, but at a pressure of 1000 pounds the water sweats through. The castings are poured in skin-dried molds and are gated from either end. The pouring heads are 10 inches high and the casting temperature is 2200 degrees Fahr. Can you suggest a better method of gating?

The following alloy is recommended: Copper, 83 per cent; tin, 6.50 per cent; zinc, 5 per cent; lead, 4.50 per cent and nickel, 1 per cent. Since the casting contains a fairly high heavy section in the center, this should be fed by a large riser to prevent shrinkage at this point. In view of the thin wall section and the high pressure to which the metal is subjected, it is probable that a hard alloy should be used and we suggest a trial of the following: Copper, 83 per cent; tin, 11.50 per cent; zinc, .4 per cent and lead, 1.5 per cent.

Liners for Diesel Engines

We build semidiesel engines ranging in sizes up to 350 horsepower. The following mixture is used for the liners for the connecting rod wrist pins: Copper, 88 per cent; tin, 5 per cent, phosphor tin, 5 per cent and zinc, 2 per cent. The scleroscope hardness of this alloy is 20. The liners made from this alloy have been entirely unsatisfactory in engines of increased horsepower.

We suggest the use of the following alloy: Copper, 89 per cent; phosphor tin, 10 per cent and tin, 1 per cent. It will be noted that this alloy contains no zinc, but is a phosphor bronze containing approximately 10.5 per cent tin and 0.5 per cent phosphorus. In place of phosphor tin, phosphor copper may be used with good results. The formula in that case would be as follows: Copper, 86 per cent; phosphor copper, 3 per cent and tin, 11 per cent. As this mixture contains 0.5 per cent more tin than the first, and 0.5 per cent less phosphorus, the alloy will be slightly harder than the former.



No. 1—Brinell, 141; Scleroscope, 38; 600 Degrees Cent. (Magnification 60 Diameters)

No. 2—Brinell, 192; Scleroscope, 57; 760 Degrees Cent. (Magnification 60 Diameters)

No. 3—Brinell, 250; Scleroscope, 80.5; 850 Degrees Cent. (Magnification 60 Diameters)

No. 4—Brinell, 254; 850 Degrees Cent. (Magnification 60 Diameters)

No. 5—Brinell, 262; Scleroscope, 74; 900 Degrees Cent. (Magnification 120 Diameters)

No. 6—Brinell, 248; 1000 Degrees Cent. (Magnification 500 Diameters)

Fig. 1—Microphotographs of 40 Gram Specimens of an Alloy Containing 10 Per Cent Aluminum and Water-Quenched at Different Temperatures

Constitution and Hardness of Aluminum Bronze

By J Neill Greenwood

THIS investigation was conducted in the metallurgical department of Victoria University, Manchester, Eng., for the purpose of determining the relationship that exists between the hardness and the composition of aluminum bronze as modified by heat treatment and by increasing percentages of aluminum. The alloys examined contained from 8.7 to 13.3 per cent of aluminum and were made from the best commercial grades of copper and aluminum, melted in crucibles and stirred with carbon rods to avoid contaminating the metal by iron. When completed, the alloys were poured into ingot molds and samples were taken from the ingots and were subjected to tempering and quenching operations. They were then polished and the hardness was determined by both the Brinell and the scleroscope methods. The samples that were used as test pieces were machined to a diameter of 1 inch and from 0.2 to 0.4-inch in thickness. They were reheated in a tube furnace and when the desired temperature was attained, were rapidly and separately removed by means of an attached loop of wire, and were quenched in water of a determined temperature. The alloys were all chill-cast and were *soaked* in the furnace for 15 minutes at the maximum temperature, in order to bring the specimen to the same temperature throughout before

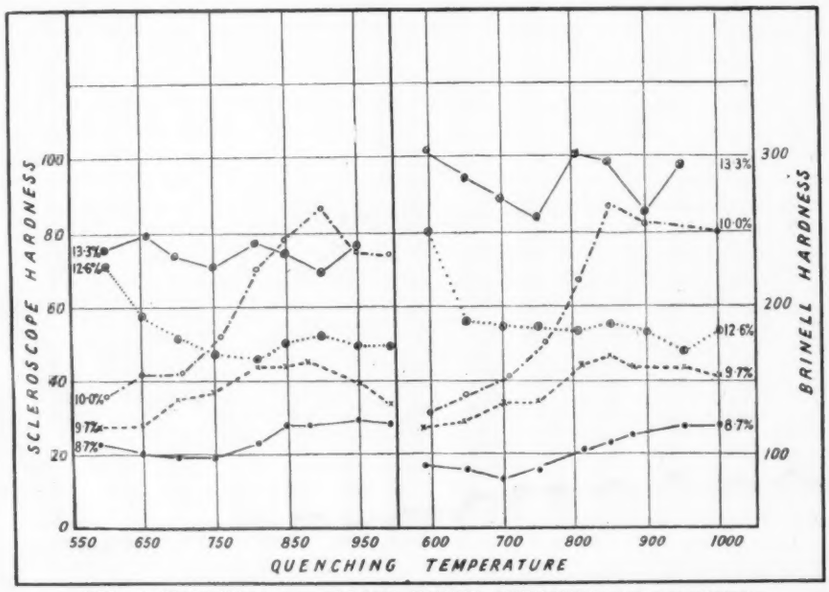
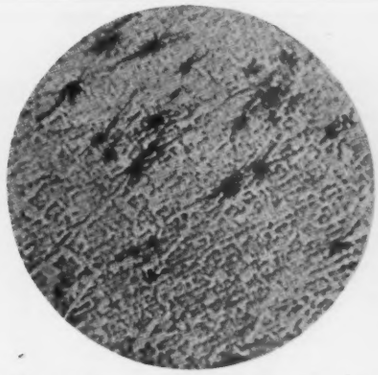


FIG. 2—HARDNESS OF ALLOYS WATER-QUENCHED AT DIFFERENT TEMPERATURES

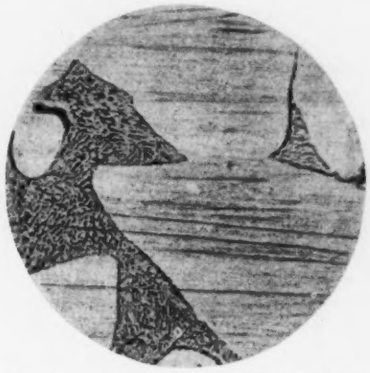
Abstracted from a paper presented before the Institute of Metals, London, Eng.

No. 7—Water-Quenched, 810 Degrees Cent.; 13.3 Per Cent Aluminum; Extreme Edge
(Magnification 150 Diameters)



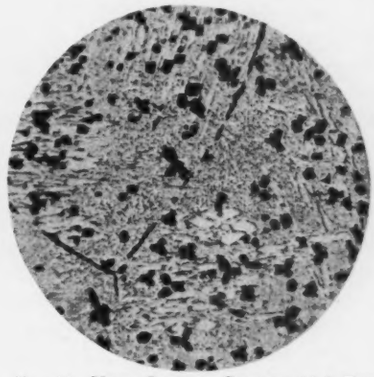
No. 8—Same as No. 7; Brinell, 303; Scleroscope, 77; Interior Unetched
(Magnification 150 Diameters)

No. 9—Annealed at 600 Degrees Cent. 13 Days; Brinell, 76; 9.7 Per Cent Aluminum
(Magnification 60 Diameters)



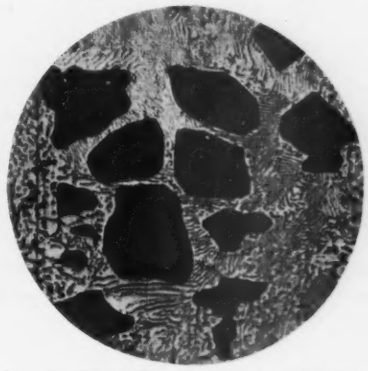
No. 10—Annealed at 600 Degrees Cent. 13 Days; 10 Per Cent Aluminum
(Magnification 60 Diameters)

No. 11—Very Slowly Cooled; 11.2 Per Cent Aluminum; Brinell, 205; Scleroscope, 44
(Magnification 60 Diameters)



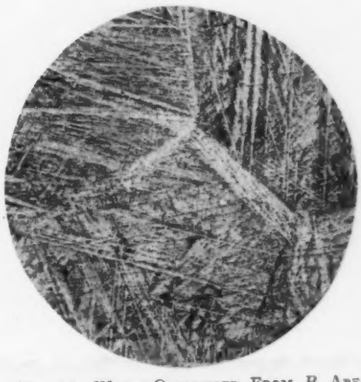
No. 12—Very Slowly Cooled; 12.3 Per Cent Aluminum; Brinell, 254; Scleroscope, 58
(Magnification 60 Diameters)

No. 13—Slowly Cooled; 13.3 Per Cent Aluminum; Brinell, 303
(Magnification 120 Diameters)

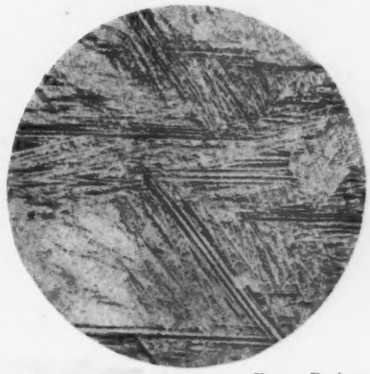


No. 14—Very Slowly Cooled; 13.3 Per Cent Aluminum; Brinell, 298
(Magnification 120 Diameters)

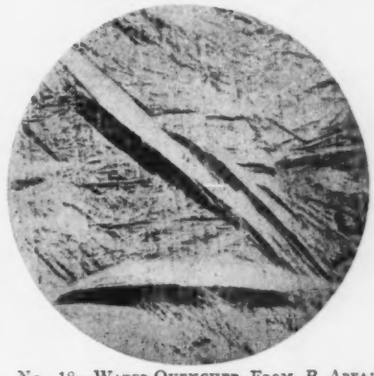
No. 15—Water-Quenched From *B* Area, 10.5 Per Cent Aluminum; Brinell, 286
(Magnification 60 Diameters)



No. 16—Water-Quenched From *B* Area; 11 Per Cent Aluminum; Brinell 232
(Magnification 60 Diameters)



No. 17—Water-Quenched From *B* Area; 12.6 Per Cent Aluminum; Brinell, 175
(Magnification 60 Diameters)



No. 18—Water-Quenched From *B* Area; 14 Per Cent Aluminum; Brinell, 224
(Magnification 60 Diameters)

FIG. 3—MICROPHOTOGRAPHS OF SPECIMENS OF ALLOYS CONTAINING VARYING PERCENTAGES OF ALUMINUM, WATER-COOLED, SLOWLY COOLED AND ANNEALED

being quenched. The temperatures were controlled by pyrometer. The alloy first examined contained 8.7 per cent of aluminum and 91.30 per cent of copper. The result of the hardness tests is given in detail in Table I, and in the diagram, Fig. 2. This alloy is softened when the quenching temperature is increased up to 700 degrees Cent., but beyond this point the hardness gradually increases until it reaches maximum on quenching the alloy from 950 degrees Cent. With further hearing, the alloy appears to decrease in hardness, as shown in Table I. Alloys containing 9.7 per cent aluminum and 90.30 per cent copper, and alloys containing 10 per cent aluminum and 90 per cent copper, are increased in hardness by the increase of temperature from which they are quenched, until a limit of 850 to 900 degrees Cent. is reached, after which higher quenching temperatures result in decreasing the hardness. The maximum hardening effect produced by quenching these alloys appears to be obtained when the alloy is heated to 850 degrees Cent., and then is quenched in water. The detailed result is given in Tables II and III, and also in Fig. 1, which shows the change in microstructure of a 10 per cent aluminum bronze produced by quenching at temperatures varying from 600 to 1000 degrees Cent.

Table I

Alloy, 8.7 per cent aluminum. Effect of quenching temperature. Pieces 1 x 0.4-in. Temperature of water, 17 to 20 degrees cent.

Weight of piece grams	Treatment	Scleroscope Min.	Max.	Avg.	Brinell 1500 kg.	3000 kg.
..	Tempered 1 hour	21	25	23	104	110
..	Tempered 22 hours	24	25	24	106	107
	Water-quenched, degrees Cent.					
46	590	21	25	23	94	97
46	650	19	22	20.5	89	97
44	700	18	21	19.5	83	93
51	750	19	21	19.5	89	95
47	810	21	26	23	103	106
51	850	27	29	28	108	117
44	880	26	29	28	113	125
52	950	28	31	29.5	118	128
50	1000	27	29	28	119	127

An alloy of 12.6 per cent aluminum, and 87.40 per cent copper, softens rapidly when the quenching temperature is raised above 600 degrees Cent., and up to a temperature of 1000 degrees Cent. there is no recovery. The same practically holds good of the alloy of 13.3 per cent aluminum and 86.70 per cent copper. The maximum hardness of these alloys appears to be attained when they are heated to 600 degrees Cent., held there for 15 minutes and then quenched in water of a temperature of 8 degrees Cent. or 46 degrees Fahr. The results of the experiments with the alloys containing 12.6 per cent aluminum and 13.3 per cent aluminum are given in Tables IV and V, and are also shown in the diagram, Fig. 2, while the changes in microstructure of these and some other alloys of the series examined are shown in Fig. 3.

Before the investigation was started a preliminary examination was made of the methods contemplated in arriving at the conclusions aimed at. These included the factors affecting the results obtained with the Brinell and scleroscope instruments, which were the thickness of the specimen, time of application of the load, magnitude of the load, distribution of the constituents of the alloy and inclination of upper and lower surfaces of the specimen.

It was found that with coarse structures of alloys consisting of two constituents of widely different hardness in making scleroscope tests, great care must be exercised, and the average of a large number of tests must be taken. The effect of coarse structures on the Brinell test is negligible.

In the case of Brinell tests the thickness of the specimen need not be more than 0.2-inch, when a load of 1500 kilograms is used to make the impression, but in the case of the scleroscope, erratic results are obtained with this thickness, and for these tests the specimen should not be less than 0.4-inch in thickness. A wide variation in the smoothness of surface of the specimen is allowable in the case of scleroscope tests. The Brinell hardness number increases with the load applied, but becomes comparatively constant with a load of 3000 kilograms and upwards. There is a linear relationship between the hardness as obtained with a load of 1500 kilograms and the corresponding hardness as obtained with a load of 3000 kilograms, the latter being obtained by multiplying the former by 1.06.

While the investigation is intensely interesting and valuable from a scientific point of view, it is doubtful if the results obtained will lead to methods that will be of practical value. This is because binary alloys of copper and aluminum are falling into disuse, owing to the great and manifest superiority of the alloys of copper, aluminum and iron. The alloys of copper with aluminum alone, containing more than 11 per cent aluminum are valueless from a commercial standpoint because of their brittleness, no matter how hard they may be. This condition is entirely modified by the addition of iron; the brittleness induced by the aluminum is counteracted by the iron and there is a definite relationship between the percentage of aluminum required to produce any desired hardness and the amount of iron necessary to counteract the brittleness that accompanies the high aluminum content. Thus, with 15 per cent aluminum it is necessary to add 12 per cent iron to counteract the brittleness produced by this amount of aluminum. The result is an alloy that has a Brinell hardness of about 350, using the 3000-kilogram weight. Further additions

Table II

ALLOY, 10.0 PER CENT ALUMINUM

Treatment. Tempered hours	Scleroscope Min.	Max.	Avg.	Brinell 1500 Kg.	3000 Kg.
1	34	35	35.0	134	145
22	27	32	28.5	135	147
Water-quenched, deg., Cent.					
590	25	30	27.5	118	135
650	25	32	28.5	122	126
700	34	36	35.0	134	138
750	36	39	37.0	136	155
810	42	46	44.0	160	172
850	42	47	44.0	166	177
880	44	46	45.0	159	178
950	36	42	39.0	159	168
1000	30	39	34.0	153	162

Weight of piece not noted. Approximately 40 to 50 grams in each case.

Table III

ALLOY, 9.7 PER CENT ALUMINUM

Treatment. Tempered hours	Scleroscope Min.	Max.	Avg.	Brinell 1500 Kg.	3000 Kg.
1	31	42	37.0	171	178
22	33	41	36.0	166	178
Water-quenched, deg., Cent.					
590	35	41	38.0	141	147
650	37	41	40.0	148	160
700	39	50	45.0	176	184
750	56	59	57.0	192	212
810	70	81	74.5	264	270
850	80	82	80.5	250	279
880	65	86	74.0	...	271
950	70	70	70.0	262	264
1000	..	..	....	248	240

of iron beyond 12 per cent result in a finer grained structure, but no increase in strength or hardness, but rather a decrease of these qualities. Between an alloy of 15 per cent aluminum, 12 per cent iron and the regular 10 per cent aluminum bronze, it is possible to obtain any hardness, desired within the range, by the addition of aluminum and iron; therefore, it is unnecessary to heat-treat aluminum bronze to get some special quality of hardness, as in the case of steels, because it is much easier and certain, as well as cheaper, to make the castings of an alloy of the desired hardness in the first place, instead of making them of a soft alloy and afterwards hardening by reheating and quenching. The ternary alloys of copper, aluminum and iron containing high percentages of aluminum and iron, are greatly benefited by a fourth constituent, and some remarkable alloys have been produced by such additions. The discovery of the effect of iron on aluminum bronze has opened a new field of research in the case of these alloys. Additional data relative to this group of aluminum alloys will be valuable.

Table IV

Alloy, 12.6 per cent aluminum.

Quenching temperature, degrees Cent.	Temperature of water, degrees Cent.	Time soaked minutes	Weight of specimen, grams	Brinell (1500 kg.)	Scleroscope
600	8	15	10.3	...	....
...	..	..	34.85	250	71
650	9	15	10.5	...	....
...	..	..	34.3	191	57.5
700	10	15	10.9	...	56
...	..	..	36.0	186	51.5
750	9	15	10.15	...	55
...	..	..	35.75	186	47
810	10	15	11.2	...	50
...	..	..	30.2	182	46.5
850	9.5	15	11.5	...	53
...	..	..	37.3	187	50
900	8	15	12.1	...	57
...	..	..	38.25	183	52.5
950	9	15	7.6	...	51
...	..	..	36.7	168	49.5
1000	9	15	9.0	...	....
...	..	..	35.5	182	49.5

Table V

Alloy, 13.3 per cent aluminum.

Quenching temperature, degrees Cent.	Temperature of water, degrees Cent.	Time soaked minutes	Weight of specimen, grams	Brinell (1500 kg.)	Scleroscope
600	8	15	7.7	...	89
...	..	..	37.4	306	76
660	9	15	9.5	...	Very variable
...	..	..	34.4	286	79.5
700	9	15	8.7	...	76
...	..	..	36.6	272	74
750	8	15	7.3	...	Very variable
...	..	..	35.5	260	71
810	8	15	8.5	...	73
...	..	..	36.4	303	77
850	9	15	7.1	...	63
...	..	..	35.3	298	74.5
900	7	15	7.6	...	73
...	..	..	37.3	262	69
950	7	15	10.2	...	76
...	..	..	35.0	295	76

Anthracite Coal for Melting Iron in a Cupola

By W J Keep

QUESTION:—Can anthracite coal be used to advantage for melting iron in a cupola? We can get this grade of coal but we are unable to secure coke. Our cupola is lined to 60 inches and the bottom of the tuyeres are 13 inches above the sand bottom. The tuyeres are continuous and 9 inches high. Our coke bed extends 24 inches above the tops of the tuyeres when the iron is first charged. The iron charges consist of 3000 pounds of iron with alternate charges of 300 pounds of coke. What size anthracite is best adapted to our purpose and to what height should the fuel extend above the tuyeres?

Answer:—The harder varieties of anthracite coal are used in cupola operations. The softer varieties of anthracite also are used, but invariably coke is charged with these grades to sustain the iron charges. It is the practice to use all coke for the bed and coal for the subsequent charges. The coal splinters and breaks into pieces as the molten iron surrounds it. In cupolas designed especially for the use of anthracite coal the tuyeres are about 6 inches above the sand bottom, but in foundries specializing in machinery work it is necessary to place the tuyeres of the cupola higher to provide storage for the accumulation of iron and this led to the use of coke for the bed. While considerable coke is recovered from the dump, practically all the coal is entirely lost. If you desire to use anthracite coal, it probably will be necessary to cut the vertical openings of the tuyeres to about 5 inches and to close the upper tuyeres entirely. Regardless of the fuel you may use, the upper tuyeres should be closed during the early part of the heat and soon after the last charge has been made, to prevent the blast from cooling the last iron. You cannot use too strong a blast with coal and when anthracite was used extensively, 14 ounces were considered the proper pressure. A melting ratio of 6 to 1 was considered good and 7 to 1 was seldom reached. When using coal, the iron seems dull although it will run satisfactorily. However, coke will melt hotter and faster and is better in every way. It hardly would be possible to obtain hard anthracite for any extended period on account of the great demand for this grade for domestic use; although the coke shortage is acute the tendency is toward increasing the by-product coke production, and since the supply of bituminous coal is practically unlimited, coke naturally will supersede anthracite entirely for melting iron. When anthracite was used extensively by foundries it was the custom to ship run of mine and to hold back the fine material breaking the large lumps to the size required.

If it is necessary for you to use anthracite coal begin by charging 150 pounds on each iron charge and use coke for the bed. In the meantime, also, use coke on your charges, but the coal can be increased 50 pounds per charge until the charges are all coal except the bed. With the use of coke and the practice of slagging cupolas, long heats were introduced, although anthracite coal was used for continuous melting and some cupolas also were slagged. As the quality of the coal obtainable is of such great importance, it is advisable for you to experiment carefully until you ascertain definitely what can be accomplished.

Hamilton & Hansell, Inc., Park Row, New York, recently have been awarded contracts for the installation of two Rennerfelt electric furnaces in the United States mint at Philadelphia. These furnaces will melt bronze and a copper-nickel alloy for coins. These furnaces will be equipped with overlip tilting and automatic side electrode feeding mechanism. Some time ago a Rennerfelt furnace of 1000 pounds capacity was installed in the Philadelphia mint and this unit, with all its electrical equipment, will be shipped to the government mint at San Francisco.

The Cleveland Blow Pipe & Mfg. Co., Cleveland, manufacturer of dust collecting systems, sheet metal shower baths, ventilating fans, etc., now is located in its new plant at 6950 Kinsman road, which provides larger quarters.

Refractory Materials Used in Casting Plants---II

The Manufacture and Application of Fire Clay Brick and Shapes Are Considered and Slagging and Other Tests Are Described

By H C Arnold

MAGNESITE used in the manufacture of magnesite brick is produced largely in Europe. There are two grades, the amorphous, produced in Greece and Norway, and the crystalline from Syria. Deposits in America are just beginning to be worked. California has notable deposits. The United States geological survey reports that in 1914, 4 per cent of the magnesite used was domestic production, 93 per cent was imported from Austria and the remainder came from Greece. Since the war, domestic consumption has increased. On the whole, however, it is extremely doubtful whether the American deposits can supply the demand as long as the foreign deposits are available, both because of the nature of the material and because of the small size of the deposits so far located. Youngman gives the following analyses:

	Crystalline from Austro-Hungary, per cent	White variety from Syria, per cent
Silica	2.75	2.50
Alumina	0.50	0.24
Iron oxide	7.00	1.00
Lime	2.50	2.25
Magnesia	87.00	93.00
Alkalies	0.75	1.00

Noncrystalline deposits in Greece, and magnesite quarries of Austria, contain magnesite in large quantities, the Grecian is used more for the sorrel cement industry and the Austrian for the refractory industry. The massive variety has a whitish yellow color, while the crystalline is blue-gray to drab and contains pieces of slate.

Magnesite is either caustic or calcine burned, or dead burned, depending upon how it is to be used. The caustic burn corresponds to the treatment of limestone in the production of quick lime. The raw magnesite is burned to from 1850 to 2000 degrees Fahr., in which state it retains about 3 per cent of its CO_2 content. This leaves the mass active and capable of recombining with various substances.

In the dead burned variety, the magnesite is burned to a sinter. All the CO_2 is removed and the substance largely loses its power to recombine with other substances. It is nonhygroscopic and has all shrinkage removed; it becomes chemically inert and in this form acts as a refractory of good quality. It is burned to a temperature of 3260 degrees Fahr. As the Austrian magnesite contains 2.5 per cent iron oxide, it will burn to a dense mass at a lower temperature than the Grecian material and still be sufficiently refractory for commercial purposes.

Magnesite brick are composed of 15 to 25 per cent low calcined magnesite, 2 to 3 per cent iron oxide added to increase the bond, and dead burned magnesite. About 50 per cent of the dead burned magnesite imported to this country is used directly in the grain form to sinter on to the bottom of open hearths and used as a cementing filler in other places, as in the basic bessemer converter.

Iron oxide is added with the original raw batch of calcine and is added to the final mix in this form. These two ingredients, calcined magnesite and dead burned magnesite are mixed together. Sometimes a binder is added, such as various tars, alkalies, etc., at the expense of the caustic magnesite. However, the common practice is to use no bond. The brick are molded by hand or pressed by steam, dried and burned. In order to provide a method of burning, compartments are built of silica brick; in these compartments the brick can be arranged in two layers or two brick on end. so that the most weight one brick bears is that of the brick on top of it. This is necessary because of the weak bond of the raw brick. The temperature of burning varies from 2160 to 3000 degrees Fahr. The increase in temperature must be slow to prevent cracking.

Properties of Magnesite Brick

The tests will not differ essentially from those on silica brick. The basic refractory, however, will not show the strength shown by the silica brick. It is ordinarily of high refractoriness, although in some cases it has been known to fail at low temperatures. The brick has a great tendency to spall and crumble with sudden temperature changes and at extremely high heat. The exact action will depend upon the chemical and physical properties of the raw material, but to a large extent also on the method of manufacturing, grinding, tempering, drying and especially the burning. Specifications have not yet been outlined for all tests on the physical resistivity of nagnesite brick. They will undoubtedly form part of the complete specifications on refractories which are being prepared by the American Society for Testing Materials. Any improvement in batch, or method of manufacture, which will decrease the tendency to spall will be a great step forward in its practical application to the industries.

Dolomite is used to some extent as a lining in place of magnesite. It is a magnesium carbonate in which part of the magnesia has been replaced by calcium. It can be obtained cheaper than the magnesite and for that reason has somewhat replaced it, but it is not satisfactory when made into brick, as it tends to crack at high temperature. It has, however, found considerable use as a lining.

With the improvements in the manufacture of silica brick, which have greatly extended their use, the fire brick have gradually given place to them in certain metallurgical processes. Magnesite and bauxite brick have decreased the use of fire brick because of their better adaptability. due to an increased refractoriness, or a more favorable chemical nature. There are, however, numerous operations in metallurgical and high temperature work where fire brick and fire clay shapes will continue to be used extensively.

Clay is an alteration or decomposition product of various minerals which have separated from igneous solution. Its history on earth may have been so varied that it has lost all trace of its original character, but the origin of all clays is traceable to this weathering action on such minerals. Natural agencies have eroded, transported, mixed and redeposited the original decomposition product and have formed beds and deposits of clays. Further action, such as plant life, metamorphism and percolating underground waters have again altered the original deposit. Thus, in the earth we have all degrees of this process from the original decompositoin product called residual clays, through the variou recently

developed beds of sedimentary clays containing impurities of all sorts, to the metamorphosed repurified beds which have the same chemical composition as the original decomposition product and which form the greatest part of our commercial fire clay deposits. The impurities present are either from the original undecomposed rock or another product of the decomposition, from admixed material during the process of transportation of the clay, or substances carried into the clay body later by action of the water. Such impurities decrease the refractoriness of the clay. They have numerous other bad effects which make the clay unfit for other purposes, but their general effect on refractoriness is the point in which we are interested.

Plasticity of Fire Clays

Such relatively pure clays are high in alumina; pure clay itself contains 46.4 per cent silica, 39.7 per cent alumina and 13.9 per cent water. Fire clays differ in the degree of their plasticity, or their ability to take up water to form a plastic mass. According to this physical property, fire clays are divided into plastic and nonplastic. The nonplastic, or flint clays, are those which develop low plasticity on treatment with water, and have a very high melting point. Plastic fire clays are those relatively pure clays which have a distinct plasticity on treatment with water and which have a high melting point or softening point. Sufficient alumina should be present in the fire clay to combine with the silica to form Al_2O_3 $2SiO_2$. Any excess of silica over this amount will act as a flux in the clay. It may be present combined with an oxide forming a silicate, but in this case the silicate acts on the clay to reduce its refractoriness. The plastic clays are generally of lower refractoriness than the flint clays and when used in the production of fire brick or shapes are used merely as a bond.

Purdy states that the fusion point of a clay is influenced by the following factors:

1.—Manner of combination of the constituents in the clay.

2.—Size of grains of the several mineral constituents.

3.—Amount, form and character of the volatile constituents do not directly affect the reactions, but the difference in the physical structure of the clay and stability of the nonvolatilized compounds caused by the expulsion of these substances affects the manner of fusion.

4.—Absorbed salts.

5.—Precipitated materials present.

These conditions so influence the refractoriness of the clay that usually one cannot infer its fusing point from the chemical analysis of the clay alone. The only safe test is a test of the clay itself. Small cones are made of the unknown clay and are heated at a constant rate until they bend over or ball up. The temperature at which this action occurs is taken as the fusing point.

Most fire clays being mined at present occur in the coal measures, usually underlying a coal seam. Large deposits are found in Pennsylvania, New Jersey, Ohio, Kentucky, Missouri and Illinois. The higher grades of plastic clays are found in New Jersey and Pennsylvania, the flint clays in Pennsylvania, Ohio, Kentucky and Missouri. The clay found underlying coal is usually pure because of the action of the ancient plant life on the salts in the clay. These plants, in search of food, removed the alkalies and salts in the clay and left it free from impurities. Fire clays, both plastic and flint, are usually mined by operations quite similar to those employed in coal mining. The vein is worked in rooms; the clay is blasted down, loaded on cars and elevated to the surface. Because of the lack of cleavage in the vein, machinery has not been used in pulling the clay down.

How Fire Clay Refractories Are Made

Fire clay bricks and shapes are made up of the two materials, flint clay and plastic clay, and a third, grog. Grog is a clay from which all shrinkage has been removed by burning. It consists of either flint clay, calcined, or old fire brick bats and shapes, ground up to be added to the batch. These three materials, flint clay, plastic clay and grog, are worked together through the preparing plant and mixed in a wet pan. Of the three constituents the plastic clay is usually the least refractory and weakest. In some cases grog, coming originally from a poor quality brick, will fail before the plastic clay, but this can be prevented by completely eliminating every kind of grog except calcined flint clay, and adding only the best flint clay as calcine. It is necessary, however, to add some plastic clay. Something is needed to bond thoroughly the flint clay and the calcine and to give the brick a sound, firm structure. This is accomplished by the plastic clay.

The proportioning of the mix will depend upon the use to which the brick or shape is to be put and where it is to be located in any given furnace. Some brick must resist high temperatures under load; others are subject to enormous abrasive action; some must resist rapid heating and cooling; and still others must resist chemical action. These considerations will influence, if not finally determine, the exact proportions of the three components which make up the brick or shapes. As an example, we may consider the action occurring at different places in a cupola or blast furnace.

Abrasion of Brick

Near the top of the shaft the fire clay sides are subject to enormous abrasive action; the raw materials fed in at the top gradually scrape their way toward the botton. Up to the point where melting first begins and a pasty mass is produced, the lining does not need to withstand a particularly high temperature, but it must be resistant to abrasion. A dense, hard material, which may or may not be highly refractory, and which usually is not, should be used. In this brick or block, the amount of plastic clay will be greater than the other constituents, because the plastic clay, reinforced with some flint and plastic clay, will give a dense, hard structure on burning. Farther down the cupola the proportioning of the mass will be governed by resistance to slag action, to high temperature and to high temperature under load conditions. Its requirements vary from low refractoriness with abrasive strength at the top, to extremely high refractoriness at the hearth and bosh. For such work in blast furnaces, hearth and bosh, inwall and top brick are made. For the hearth and bosh, the brick are made of maximum refractoriness; for the inwall they are made for refractoriness and strength in abrasion; and for the top, the brick are of a dense and tough structure. In a similar way with other operations, the proportioning of the material will depend upon the operation and action which the brick must resist.

After the three ingredients are thoroughly pugged together, the plastic mass, commonly called the pug, is aged, to produce a homogeneous material with a uniform water content which will allow a uniform shrinkage. Molding and drying is quite similar to the methods used in the manufacture of silica brick. The temperature of burning is from 2550 to 2650 degrees Fahr. Coal or producer gas is used. After reaching the maximum tempertaure the firing is stopped, the kiln is sealed up for three or four days and the brick allowed to anneal. Cooling to normal temperature takes three or four more days. The brick are then removed, stored or shipped.

Before fire brick is put into use

a sample brick should be subjected to certain tests which reproduce as nearly as possible the action which the brick will becalled upon to resist while in a structure. Those brick which show up best in these tests are the ones which will naturally be used. Such tests are tests for compression, cross-breaking, strength, spalling, resistance to abrasion, action under load at high temperature, slag, refractoriness, thermal conductivity, coefficient of expansion, etc. It is the work of the American Society for Testing Materials to study various aspects of the problem and to specify those tests which will show in a practicable manner the future action of any given material in its application to the work for which it was intended.

Nesbit and Bell in *Transactions* of the American Society for Testing Materials, have worked out a series of tests for fire bricks which can be conducted at any plant at a small expense and with very desirable results. They use tests for impact, abrasion, spalling, slagging, compression, expansion and contraction. Two other important properties which should be tested by a plant are the fusibility and load resisting qualities.

The impact test is used to test the quality of brick to resist impact. A brick to be tested is heated to 500 degrees Fahr. and held for three hours; it is then placed on a steel block so that a ball, dropping, will hit the exact center of the up-ended brick. The ball, 2½ inches in diameter, is dropped from heights increasing by 2 inches until the brick is fractured. The distance in inches of the last drop is the result of the test. The results show that a brick at 500 degrees Fahr. is 20 per cent weaker and at 1000 degrees Fahr. is 40 per cent weaker than the same brick at 68 degrees Fahr.

Conducting Abrasion Test

The abrasion test is conducted with a carborundum wheel to show the resistance to abrasion, when the brick is heated to 500 and 2460 degrees Fahr. The wheel is a vertical carborundum wheel with 2-inch face, 18-inch diameter, and is mounted on a stand. The brick is placed on a plate in front of the wheel; the surface of the plate is 1¼ inches below the center of the wheel so that the center of a 2½-inch brick will be at the center of the wheel. Pressure on the brick is equal to 10 pounds per square inch against the surface of the wheel. The brick is ground to a thickness of 2.35 inches and the ends ground so that the wheel in the test cuts through this exact thickness. The depth of the preliminary cut is then taken, the brick heated up slowly to 2460 degrees Fahr. in six hours and held there for three more hours. It is then removed, placed flat on the plate in front of the wheel and held in contact for five minutes. The brick is then returned to the furnace, reheated for one hour and the test repeated on the opposite end. The result is the difference in depth between the preliminary and final cut in inches. The work of Nesbit and Bell developed the fact that brick had different resistances to abrasion at opposite ends.

In the spalling test, the furnace is first heated to 2400 degrees Fahr. and held at this temperature for one hour. The brick are dried at 210 degrees Fahr. for five hours, weighed and placed in the doorway of the furnace for one hour. They are then removed, plunged into two gallons of water at 68 degrees Fahr. to a depth of 4 inches and held for three minutes, removed and allowed to dry for three minutes. The operation is repeated 10 times. The brick are then dried at 212 degrees Fahr. for five hours, all loose particles removed and the brick weighed. The loss in weight represents the tendency to spall.

Conducting Test on Slagging

From a number of experiments Nesbit and Bell came to the result that the best method of testing the brick for slagging was by drilling holes partially through the brick and filling them with the slag to which they would probably be exposed in use. The length of the brick is bisected by a line, and in the center of each half a hole 2½ inches in diameter and ½-inch deep is drilled. The brick are placed level in a cold furnace and heated to 2460 degrees Fahr. as before. At this temperature 35 grams of standard blast furnace slag are placed in one cavity, and 35 grams of standard heating furnace slag in the other. The brick are held at this temperature for two hours after the slag is added. At the end of that time the furnace is cooled, the bricks are sawed longitudinally directly through the center of the cavity. The area of penetration is determined and from this is subtracted the original cross-section. The difference is a measure of the action of the brick towards the slag.

Nesbit and Bell's tests for compression was by measuring the penetration of a steel sphere under a given load. The brick rests upon a solid foundation; directly over the brick is a channel iron, fulcrumed at one end, and with weights applied at the other, the total weight being 1600 pounds. The brick is heated as before, removed and placed flat beneath the bar. A spherical impression in the bar marks the position of the ball. The ball is then put in contact with the center of the brick and the depression in the bar. Weight is applied immediately and maintained for five minutes. The depth of the impression is a measure of the compressive strength of the brick at high temperature.

In determining expansion and contraction, the brick is heated as in the compression test and the length measured before and after heating. The result in inches per foot gives the normal expansion and contraction.

Determining Compressive Strength

A method of determining the compressive strength at high temperature has been worked out by Bleininger and Brown. Their work in this connection is exhaustive; it not only brings about a measure of load carrying capacity of the brick at high temperature, but it also indicates how the brick fails, what compounds are the first to give way and how a better body could be developed.

Depending upon the amount of deformation at 2460 degrees Fahr. and 50 pounds pressure per square inch when held for one hour, they have proposed the following classification:

1 (*A*).—Those clay refractories which do not show a deformation below cone 31 or 3182 degrees Fahr., and when tested for load-carrying capacity will not show a deformation of more than 1 inch in 9 inches. Later specifications change this to ½-inch.

1 (*B*).—Those refractories which withstand a temperature up to cone 31, 3182 degrees Fahr. and in load-carrying capacity will not show a deformation more than 1 inch in 9 inches under a load of 30 pounds pressure per square inch.

No. 2 Refractories.—Those which will not soften below cone 28, or 3074 degrees Fahr. They should be able to withstand a load of 25 pounds per square inch at 2380 degrees Fahr. without contraction of over 1 inch in 9 inches.

Similar tests made on every shipment of brick or shapes used in a structure will determine to a large extent their value for a particular operation. Those brick should be used which show the greatest resistance to the particular action to which thy will be subjected when in use. Other tests may be devised for special cases; any arrangement which will indicate in a short time how a certain brick will act in a certain place will aid in the selection of the right bricks for that place. If all operators would conduct such

tests it would undoubtedly bring to them a more thorough knowledge of the refractory materials.

Other refractories are bauxite brick, chrome brick, materials containing carbon as the chief refractory, carbon-silicon compounds, cement, mortars, the metal refractories, and many others. A discussion of the use and preparation of all these different substances would, however, lead too far afield. Of most importance to the iron worker is probably the chrome brick, which, because of its great refractoriness, can be used in the basic open hearth as a buffer lining between the magnesite and silica. Chromite is found as a chrome iron ore, a dark, metallic, splendent mineral of extreme hardness, containing 40 to 50 per cent chromic oxide. Although chromic oxide itself is extremely refractory, the chromite ore mixed with iron oxide, alumina and silica, is much less refractory. It is, however, sufficiently resistant to withstand the temperatures in the open hearth and its neutral nature makes it very resistant to the slags formed in the melting.

The greatest deposits and practically the only ones which are being worked at the present time are found in Greece. The material occurs in Asia Minor, in Cuba, Styria, in the Urals, in Pennsylvania, Massachusetts, Maryland, Georgia, New York, North Carolina, Oregon, Virginia and California. It is first crushed and picked by hand, then ground in dry or wet pans, mixed with a binder which may be fire clay, magnesia, lime, dolomite, or one of several others. Only enough water to give the body a bonding power is added. The burning is similar to magnesite brick. Two bricks are placed together on ends in compartments made with silica brick.

Various reports are given as to the strength and action of chrome brick while in operation. Havard reports that they are unreliable at a temperature above 2730 degrees Fahr., and that at 3270 degrees Fahr. they become soft and crumbly. American practice, however, is to use them wherever a neutral lining is desired.

Molding and Casting Bronze Tablets

By W B Jones

As indicated by recent inquiries published in THE FOUNDRY, considerable interest seems to be manifested in the molding and casting of bronze tablets. Therefore, the methods furnished by the Gorham Mfg. Co., Providence, R. I., may prove of value. This company's foundry casts tablets every day. Among the recent examples of this work were the tablets for the Vicksburg battlefield, which were of unusually large size, with fine letters and undercut parts. In the latter case, cores were separately made and dried and were secured in the mold in their proper places.

The making of tablets involves no secrets and any good molder should be successful, provided he starts the job right. It is advisable to use French sand, and it should be prepared by grinding with burnt sand of the same quality. When making the mold it is important to avoid *ramming away*. This may be accomplished by exercising care and by the use of a strip or bar of lead back of the ramming to act as a weight and to prevent the slipping of the sand; otherwise, the mold will scab when the molten metal runs over it. The molds are always dried in an oven before being poured and the French sand must be rammed hard.

The arrangement of the gates is the most important feature of the work. We use wedge gates placed on the backs of the tablets, but these do not cut through the cope. They are merely wedges, 2¼ inches high, 2 inches long, ¼ inch wide on the thick end and ⅛ inch wide on the thin end. The number of wedges used is governed by the size of the tablet. When beginning to ram the cope, sand first is screened over the back of the pattern; the runner wedges then are set in place and are held by tucking the sand; after the cope is rammed until the sand comes up to the top of the wedges, a short length of brass tubing, 1 inch in diameter, is laid lengthwise on top of each runner wedge. The ramming is continued and a parting is made along the parting lines of each tube, just as if the tube were to be molded lengthwise. The tubes and the wedge gates underneath them are renewed and a stick of tallow, cut to the proper length and of the right diameter, is dropped into the prints left by the brass tubes. This tallow cylinder covers the openings left by the wedge gates and prevents them from being choked by sand during the continuance of the ramming of the cope. The cylinders of tallow are left in the mold, and are burnt out in the oven when the mold is dried.

The tallow cylinders are made by pouring melted tallow into sand molds. A piece of tubing of the proper size is wrapped with paper and is rammed upright in a sand mold. When the tube pattern is removed, the paper lines the cavity and keeps the melted tallow from penetrating into the sand, and also keeps the sand out of the tallow. The tallow is poured into the paper-lined sand molds, and when cold is removed and is ready for use.

The runners must be arranged on top of the tallow cylinders rammed in the molds, so as to meet together on top of the cope converging at one point. After the cope is rammed and the runner sticks are removed, each one has made a circular, inclined passage reaching from a common point on top of the cope to one of the little tallow cylinders concealed in the sand of the cope. Each runner connects with its tallow cylinder, about midway its length. After the cope is lifted, the wedge gates are filleted at the point of their junction with the back of the tablet, and all loose sand is removed from the gating system. After the mold has been baked, the tallow cylinders which have melted have disappeared and each wedge gate slit has a clear and continuous opening to a central converging point on top of the cope.

When the mold has been closed, it is prepared for pouring by having a runner box placed over the runner openings to permit pouring the mold with one ladle. Great care must be exercised in setting this runner box to prevent a runout. A sheet of paper is first laid over the runner openings in the cope to prevent the possibility of loose sand falling down into the mold. Paste is next spread on the cope surface around the runner holes and a cylindrical wooden pattern is placed upright over the holes. Next a frame, 2 inches deep and of sufficient size to provide a base for the runner basin, is placed on the cope so that the runner pin will be centered in the frame. The frame then is rammed with sand and a joint is made level with its top. The runner basin is then placed and rammed and the runner pin is removed and a plug is fitted into its upper end. The plug is attached to a rod with an eye in its end, and when the mold is poured the plug keeps the metal from running into the mold before the runner basin is filled. When the basin is filled the plug is withdrawn and the metal quickly fills the mold. The runner basin is kept full while the mold is being poured and after it is filled, the surplus metal left in the basin is then tapped out.

Interesting Examples of Practical Patternmaking

By J L Gard

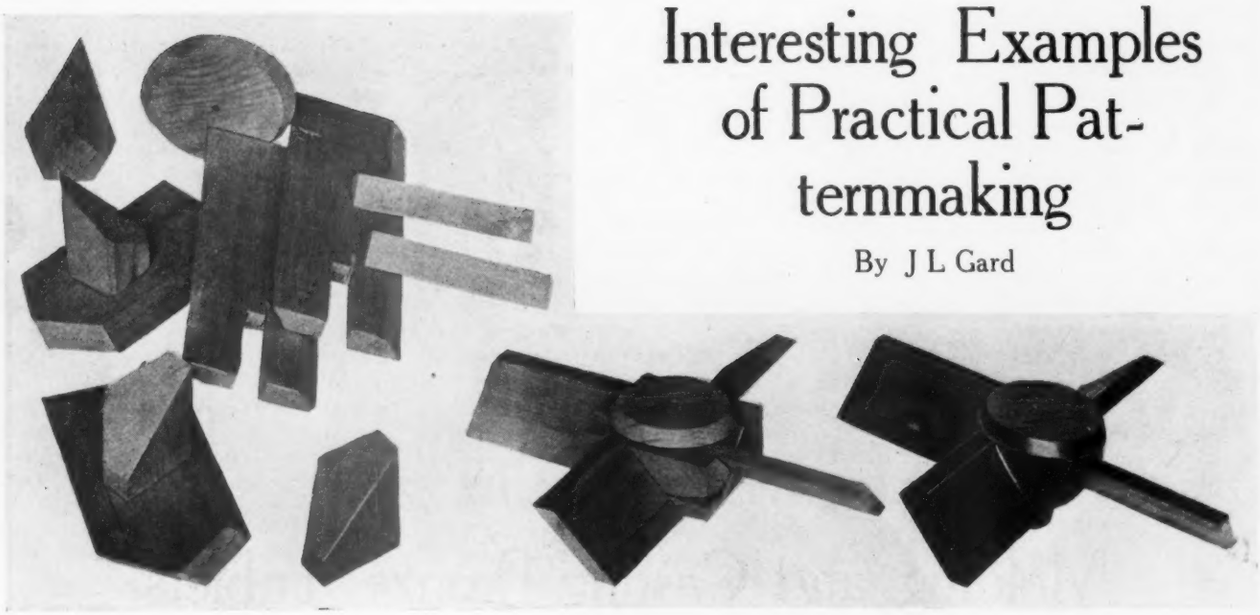


FIG. 1—THREE STEPS IN MAKING A PATTERN FOR A MIXING BLADE SPIDER. THE LOOSE PIECES AS THEY COME FROM THE RIP SAW, THE SAME PIECES ASSEMBLED AND THE FINISHED PATTERN

THE accompanying examples of practical wood patternmaking were taken from everyday work to illustrate how efficient methods can save time in the pattern shop.

At the left in Fig. 1 are shown the pieces used in constructing a pattern for a 15-inch diameter mixing blade spider. The angles of the blades are 45 degrees. All the angles shown in the illustration, except the angle of the circular hub, were cut on the rip saw. At the center of Fig. 1, these blades are arranged to show their assembly, while the view at the right shows the finished pattern.

The method used in getting out these pieces eliminated a large amount of hand work. As it was, the hand work consisted only of trimming the hub between the arms to the line formed by the periphery of the turned boss and forming the draft from each side of the hub. The core print for the hub core was on the bottom side of the hub only.

It is common practice to glue up solid patterns of this kind, before working out the angles of the blades or the shape of the hub. This procedure is expensive when compared with the method illustrated. As a matter of fact, the time consumed in making two patterns of the type shown in Fig. 1, a right and a left hand, was only a little over five hours.

Making Duplicate Patterns

It is often necessary to make several patterns that are exact duplicates. Such a pattern is shown in Fig. 2. In this case, 140 castings for commutator bars were wanted and 14 patterns were to be made. The first step in making these patterns was to shape the piece *A*. This was made wide enough to cut into 14 pieces of the desired thickness. Piece *B* also was made wide enough to cut into 14 projections of the desired thickness.

After cutting the 14 pieces from *A* they were planed to fit the gage *D* and tested between the sticks on another gage *E*. The angle between the sticks on *E* is 36 degrees or 1/10 part of a circle. The diameter of the gage is the same as that of the armature hub, due allowance having been made for the mica insulation. The projecting pieces were glued in place in saw cuts made for this purpose and the patterns were then complete. The patterns were 8 inches long and $\frac{3}{8}$-inch thick. The time required to finish them complete was four hours.

The method used in making patterns for beveled washers is shown in Fig. 3. The first step in making patterns for square washers with a slight bevel is shown at *A*. This piece has been

(*Concluded on page* 340)

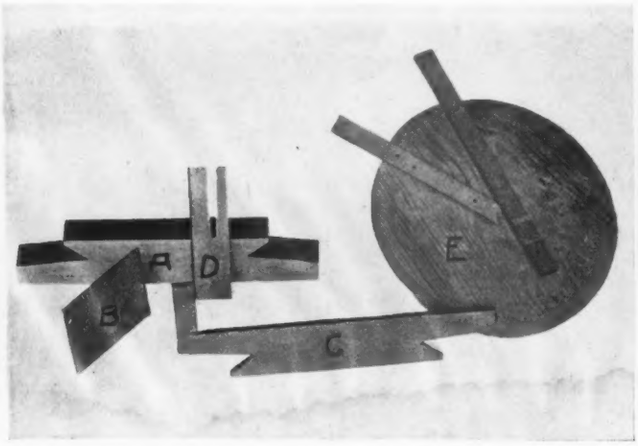


FIG. 2—SIMPLE METHOD TO FOLLOW IN MAKING SEVERAL DUPLICATE PATTERNS

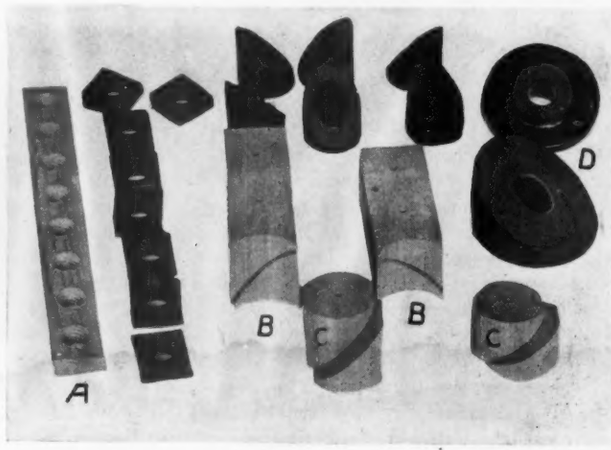


FIG. 3—EFFICIENT METHOD TO EMPLOY IN MAKING PATTERNS FOR BEVELED WASHERS

Preparing Metal Parts for Electro-Plating---I

Polishing Wheels and the Polishing Process Are Discussed, With Details Regarding the Construction of Wheels, Uses of Abrasives and Operating Speeds

By E P Later

IN our discussion of the problems connected with the art of electro-plating we may easily fall into the error of considering only those which relate directly to the actual deposition of the metal from the plating bath, disregarding those preliminary operations upon which so much of the production of a satisfactory finish depends. No matter how efficiently or well our plating bath functions, it is only one link in a chain of operations which are necessary for the production of high-grade work. Unless those which come before it and have to do with putting the parts into proper condition for the application of the real finish are carried out as they should be, the final results are certain to be less satisfactory than could be desired. Indeed, it is not uncommon to have a finish entirely spoiled through some lack of care and attention in the earlier stages of the process. .

Now-a-days, however, it is not enough to know that a certain operation or set of operations has been performed in such a manner that the results are good; we must have some assurance that the work has been done in the most efficient way. With this idea in mind it may be interesting and helpful to consider in this and a succeeding article some of the principles involved and the methods employed in the process of putting the work into the proper condition to receive the final finish.

Grinding or Polishing the Objects

The first operation to which a great many of the parts received in the plating room must be subjected is grinding or polishing; the surface is rough and scratched or otherwise in poor condition, from the finisher's standpoint, and must be smoothed down. There are several different types of polishing wheels, each made of different materials and possessing certain advantages for particular classes of work. Probably the first polishing wheel on the market was built of wood, the edge or face having been covered with heavy leather, such as the ordinary oak-tanned kind, bull neck or walrus hide. The wood wheels now in use are built-up of cross-banded sections to give the strength required to prevent them from flying apart under the centrifugal force developed while in use.

The leather facing is stretched and glued on tightly and then wooden pegs are usually driven through it to give additional strength. Such wheels are serviceable in cases where a smooth and firm surface is needed. The face is sometimes turned or shaped to fit the work, although this is not done so much now as formerly.

Wheels made of canvas are widely used in metal finishing and are to be had in three types. What are termed solid wheels are made up of discs of canvas, the exact number, of course, depending on the width of the wheel, which are cemented and then subjected to heavy pressure in an hydraulic or other press. Wheels made in this manner are comparatively hard and solid.

Making a Soft and Resilient Wheel

A softer and more resilient wheel is made by hand sewing a few discs together to form a section and then cementing several of these sections together as in the previous instance. The bond between the different layers of canvas is less strong than in the former instance, with a consequent gain in elasticity. A still softer wheel is made by merely sewing the discs together, omitting the cement.

Leather wheels enjoy a good deal of popularity, particularly among those finishing certain classes of metal goods such as stove castings, forged steel and iron parts, etc. These wheels are made by cementing together discs of bull-neck leather and then subjecting them to heavy pressure. When properly made and used they give satisfactory service and admit of being employed not only for the rougher polishing, but likewise as a grease-wheel for the production of a much finer finish. When desired they may be shaped to fit the surface of the work.

Walrus hide, although expensive, is used in about the same manner. Wheels made of it, perhaps, are better suited for the production of a real high-grade polish than any other wheel and are largely employed in the finishing of firearms and cutlery.

Felt wheels are put on the market in several different qualities or grades and various degrees of hardness, ranging from extra soft to rock-hard. As the name indicates, these wheels are made of wool, the latter coming from some of the western states. The wool is first put through various cleaning and refining processes after which different grades are thoroughly blended and mixed together, according to the type of wheel desired. Other treatments which need not be detailed here are then applied, ending with a careful and thorough drying-out, which is accomplished by placing the rough wheels in a drying chamber maintained at a uniform temperature. The surface is lined-up and made smooth by passing the wheels through sandpaper rolls. A period of seasoning ensues after which the face is turned flat and true and they are then ready for use.

Laminated felt wheels are made either by cementing together comparatively thin discs of felt with a flexible cement, thereby producing what is known as the solid wheel, or these discs may be sewed together in a circular fashion from hole to circumference.

Felt wheels are suitable for a very large variety of work and conditions and may, perhaps, rightly be regarded as the most useful all-around wheel. Set up with glue and emery they are satisfactory when used for polishing preliminary to buffing or plating; by removing the glue and emery and substituting rouge or buffing materials therefor, a buffing wheel of rather superior qualities may be produced.

Felt and Sheepskin Wheels

Felt wheels have a nap, that is, the surface is smoother when rubbed in one way than when it is rubbed in the opposite direction; this is due to the "lay" of the fibres and the wheel should be placed in the lathe in such a manner that the nap is smoothed down as the work rubs against it. Further, a considerable amount of heat is developed during polishing and it is possible to start a felt wheel

smouldering if the pressure is too long continued. The fire may then eat its way along for a considerable distance before it is noticed; attention is often directed to it by the pounding of the wheel as a result of having been thrown out of balance. A felt wheel which has been damaged in this manner by fire must be cut down until all of the burned or charred material is removed.

Sheepskin wheels are made either by cementing a number of layers or discs together, in which case a moderately hard and firm wheel results, or the discs may be stitched together either from hole to circumference or merely at the hole, depending on the firmness desired. As might be expected the loose wheels are used largely for work which is of very uneven or irregular shape.

Preparing Wheels for Polishing

Before they are ready for use, polishing wheels must be set up, given a coating of abrasive or cutting material, and inasmuch as there is a number of such materials in use it may be interesting to consider some of them briefly. Emery is perhaps the most widely known and has been used the longest of any of the other abrasives. It is a natural mineral and is found to some extent in this country, although some of the best grades, before the war, were imported from certain foreign countries. Emery is a mixture of crystalline oxide of aluminum and iron oxide; as a general rule the mixture is roughly 60 percent aluminum oxide and 40 per cent iron oxide. It is rather interesting to note that only about two-thirds of a given quantity of emery is of such a nature as to cut efficiently, inasmuch as the iron oxide possesses only slight abrasive qualities; the aluminum oxide is much harder and cuts much better than the other.

Corundum is a pure form of emery found in nature and containing 80 per cent or more of aluminum oxide. The supply is rather limited, however, and it finds only a moderately wide use; this is partly because the electric furnace has made it possible to produce the most useful abrasives. It is a natural mineral and of very uniform quality suitable for ready use.

For the sake of convenience artificial abrasives may be divided into two general classes, according to their composition. The first, known as the aluminous group, contains aluminum oxide as the base. They are on the market under such names as alundum, adamite and aloxite. The other may be designated as the carbide of silicon group. These are sold under various trade names, such as carborundum, xolon, crystolon and so on.

The first class of abrasives, the aluminous, contains approximately 90 per cent of aluminum oxide, the other 10 per cent consisting of various impurities such as silica and oxides of iron and other metals. The manufacture of these is simple enough in its broad aspects and consists in fusing some material high in aluminum oxide in the electric furnace; in practice either emery or a certain clay known as bauxite is used, the latter being more satisfactory, is more widely employed. At the end of the heat the abrasive floats on top of the melted mass as a sort of slag. It is allowed to cool and is then broken up and crushed by heavy rolls to the desired degree of fineness; this may vary from pieces somewhat less than ⅛ inch in diameter to a powder so fine that it can be suspended in water for a considerable length of time. This type of abrasive is used to a greater extent than the other for polishing; this is probably due to the greater difficulty which is experienced in gluing the other to the polishing wheel.

The silicon carbide abrasives are manufactured in about the same way as the others; coke, sand, sawdust and salt are heated in a resistance type electric furnace to a sufficiently high temperature to cause the carbon of the coke to unite chemically with the silicon of the sand. The color of the resulting product, which of course contains a certain amount of impurities, varies considerably and the slight differences in composition, both accidental and due to the furnace treatment, are sufficient to affect the commercial uses. Of course, the massive silicon carbide is crushed and graded to the sizes desired for the class of work at hand.

Hardness and Toughness

While on the subject of abrasives it may be noted that the value of these materials depends largely on two qualities, hardness and toughness. If the material used for cutting is not sufficiently hard the sharp edges soon become dull and the efficiency drops rapidly. On the other hand, hardness and brittleness are often associated, but a satisfactory cutting material must not only be hard but it must be tough enough not to shatter or crumble too much under the conditions to which it is subjected in cutting its way through the metal or other substance. Of course the abrasive is gradually broken up and removed during the grinding or polishing process, but the individual grains should split in such a fashion that fresh, sharp cutting edges are formed.

It is not hard to see, therefore, that there is no economy in using a poor grade of abrasive, for the cutting efficiency will probably be so low that what ever is saved in the first cost of the material will be lost many times over in the greater length of time required to turn out a given amount of work, the diminished output of each wheel and the necessity of setting up the wheels more frequently.

Naturally the character of the work is a factor of some importance in the selection of the proper abrasive, since all abrasives do not give equally good results on all classes of work, and a little judicious experimenting will probably be of much assistance in determining the material best suited to the conditions.

Applying Polishing Wheel Properly

After the selection of the abrasive perhaps the next important item is its proper application to the polishing wheel and it is on this point that there is room for a considerable improvement in the practice of many plating establishments. Not only is the grade of glue to be used worthy of some consideration, but the handling which it receives incident to its application should be given careful attention and a few suggestions regarding this feature may be helpful; one should not lose sight of the fact that unless the abrasive is attached to the wheel as firmly and solidly as possible, it will not be able to work to the best advantage. In several instances I have known the abrasive to be blamed for poor service when the trouble lay in the materials and methods used in applying it to the wheel.

Only the best grade of glue should be used and it should be borne in mind that prolonged heating, allowing to solidify and then remelting repeatedly, or heating above certain limits reduces the strength of the glue markedly; therefore, such treatment should be carefully avoided. In a practical way this means that the glue should be prepared only in small quantities, say, just enough for the day's needs. Further, it should be heated only in water-jacketed pot, never over a direct flame or on a hot-plate, and it is advisable not to let the temperature of the glue rise much above 150° Fahr. The glue pot should be cleaned out frequently

and if it is kept covered, not only will dust and dirt of various sorts be prevented from getting into it, but the evaporation of the water will be retarded considerably.

It is rather difficult to say definitely how heavy or thick the glue should be made, if only for the reason that the requirements vary somewhat according to the conditions. A formula which is generally used calls for a pound of glue to a pound of water, one pint, and this will be found to give good results with the coarser grains, up to No. 45 or thereabouts; for the finer sizes it is advisable to make the glue thinner.

After the glue has been brushed onto the face of the wheel the latter should be rolled back and forth in a box or trough containing abrasive of the desired size and then allowed to dry in a moderately warm place for about 12 hours.

Wheel Must Be Well Balanced

Another point to be remembered in connection with the use of polishing wheels is that they must be true and well-balanced. In one way or another a wheel may get into the condition where all parts of the face do not come into contact with the work; there are bulges or depressions in it. To determine whether a wheel is running true it may be revolved on a spindle and a piece of chalk or an old file, firmly held on a temporary rest, cautiously brought into contact with it. It is then easy to tell whether the wheel touches the object evenly all around and if it does not, the face should be trued by holding an emery stick or old file against it. For the sake of any who may not be familiar with the emery stick, it may be said that this is a very useful article to have around the polishing room and may be made by coating a small stick of wood with glue and then dipping it in the emery box; this process should be repeated several times, until the coating of glue and emery is quite thick.

When a wheel is out of balance it means, of course, that one side is heavier than the others and this condition can be detected by placing the wheel on balancing ways or some such device where it is free to turn with the least possible friction. Under these conditions the heavier side will roll to the bottom. The usual practice is then to nail small pieces of lead into the light side until the wheel exhibits no tendency to come to a rest when one particular side is down.

Finally, the matter of running polishing wheels at the proper rate of speed is of prime importance. When we polish a metal surface we are removing the outer layers, so to speak, making the sharp edges of the abrasive cut away whatever irregularities there may be and leave the part comparatively smooth, although scratches or furrows where the metal has been gouged out will be visible, of course, unless the abrasive is very fine.

Considering an abrasive of a certain degree of fineness, at a single revolution of the wheel one grain alone does not accomplish very much; in effect it merely makes a more or less deep scratch on the surface, but by multiplying the number of grains many thousands of times the total effect is correspondingly greater. If now the number of times that a grain comes into contact with the work in a given period is increased many thousandfold the effect is still further enhanced and as a result a comparatively large amount of metal may be removed in a very short time. It is clear, threfore, that, other things being equal, the speed with which polishing can be done depends upon at least two factors: the number of grains of abrasive available for active cutting and the rapidity with which these can be brought again and again into contact with the metal surface. Beyond seeing that the face of the wheel is covered with as much abrasive as the glue will hold there is not much that can be done as far as governing the number of grains is concerned, but when it comes to the other factor, the speed, that is a matter which is under complete control. Incidentally, it is one to which the proper amount of attention is very frequently not accorded.

Calculating the Linear Speed

Ordinarily the speed of machinery is designated as so many revolutions per minute, r. p. m., a term which often gives us all the information desired, but in certain cases, polishing is one of these, it is not enough to know the shaft or spindle speed; this does not tell the whole story. In this particular instance we want to know the speed with which the abrasive is carried past the metal surface, the linear speed, in other words; therefore, it is necessary to know not only the speed of the spindle, but the diameter, circumference or radius of the polishing wheel; knowing these it is easy to calculate the linear or peripheral speed. For instance, suppose we have a wheel 10 inches in diameter on a spindle revolving 3000 r. p. m. and wish to know the linear speed. 10 times 3.1416=31.42, approximately, which is the circumference of the wheel. That means that one turn of the wheel carries 31.42 inches of abrasive past the work. Since the wheel is revolving 3000 times a minute, 3000 times 31.42=94,260 inches or 7855 feet, somewhat less than 1½ miles of abrasive are carried past the work in one minute. Experience has shown that this is about the proper speed for ordinary work. If the speed is too low the rate of cutting is decreased considerably, and, in addition, the abrasive is torn from the wheel too easily, whereas at a higher speed it literally does not have time to be torn loose; it is not in contact with the work long enough.

Determining the Speed

To turn the problem around somewhat, suppose we have a wheel 12 inches in diameter and wish to know at what speed to run the spindle in order to obtain a perihperal speed of 1½ miles a minute; 12 times 3.1416 =37.7 inches or 3.142 feet, approximately, which is the circumference of the wheel. Inasmuch as there are 7920 feet in 1½ miles, we must find what number 3.142 must be multiplied by to give 7920; this is done by dividing the latter number by the former; 7920 divided by 3.142=2525, which is the proper r. p. m.

The calculation of problems of this sort is so simple that further examples need not be given; in any case information on such points can be found in any handbook of mechanics.

Polishing wheels gradually become smaller in service, therefore, they outgrow, as it were, the spindles which were formerly suited to them in the matter of speed and it becomes necessary to use them on spindles which revolve at higher rates; it follows from the foregoing that the smaller the diameter of the wheel the greater must be its revolutions a minute in order that the face may have the requisite linear speed. This is a point which should be closely watched. When there are a number of polishing machines in use it is usually possible to have one or more whose spindles revolve at a speed suitable for new or large wheels. One or two other machines can be run at a somewhat higher rate and when the wheels get too small for satisfactory service on the first machine they should be transferred to the second and so on through as large a series as is possible or desirable. With a little attention a scheme of this sort will make it possible to operate all of the polishing wheels at a speed which will give very nearly the maximum efficiency.

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Conserving the Foundry Output

IN SUGGESTING to the stove and furnace industry that it practice pig iron conservation by reducing the number of styles and sizes of its output, the government has taken a step in the right direction, which is welcomed by the manufacturers themselves. Competition in this trade has been so keen that it has been considered necessary, to keep abreast of the times, to place on the market new designs, with an accompanying range of sizes for each season's campaign. The expense involved to the entire industry has been enormous and it is doutbful if the profits derived compensated for the effort. By this course of procedure, which has been followed for more than half a century, the various lines have been added to greatly, with the result of accumulating stock sizes that represented not only a tremendous investment, but also a large tonnage of iron. It is for the purpose of conserving the pig iron supply that this recommendation has been made, and as it undoubtedly will be carried out faithfully it will result in an enormous saving, not only in iron, but in expense to the manufacturer. The same situation exists in the furnace trade where competition forced changes almost every year. An attempt at standardization of agricultural implements also will be made and if carried out will prove a boon to the implement dealer and also to the farmer. Spare parts in warehouses throughout the country aggregate a large total, not only from the standpoint of investment, but also in tonnage of iron. This conservation policy is well conceived and bears adoption by every manufacturer involved. We have been a tremendously extravagant nation and war time economies undoubtedly will be carried into our trade of the post-war period with beneficial results.

Saving Coke

HANDED down from father to son in the foundry industry has been the admonition that hot iron will produce sound castings. The coke consumption was given little consideration as long as the castings came clean and the percentage of wastes were low. Our country had an adequate fuel supply that could be obtained at a comparatively low cost and, therefore, the fuel ratio was not given the attention which it deserved. With the advent of the war conditions have changed. Coke has more than doubled in price and the quality does not measure up to that formerly obtainable. Besides, the supply is limited and the transportation facilities are inadequate. Foundrymen must study their melting problem with a view to increasing their fuel ratio and thereby conserving the coke supply. Comparatively few shops are melting with a minimum amount of coke. In too many plants the fuel is measured by the scoop and not by the scale. Too little consideration is given to cupola charging by the superintendent or foreman. If you do not know how to solve your melting problem call in someone who does. He will save you hundreds of dollars in a very short time and you will be rendering your country a patriotic service in its hour of dire need. Protect your coke piles from the weather. Every pound of moisture requires fuel to expel it. Wet coke retards melting. Dry coke hastens it. Keep your coke dry.

Personal

F. P. Burgoyne, Lima, O., was recently made factory superintendent of the Modern Iron Works, Quincy, Ill.

Thomas Finigan was recently elected vice president of the American Brake Shoe & Foundry Co., with headquarters at Chicago.

Frank Rhodes was recently appointed factory metallurgist of the Aurora, Ill., plant of the Independent Pneumatic Tool Co., Chicago.

C. H. vom Bauer, active in the electric furnace field for the past eight years was recently elected vice president of the T. W. Price Engineering Co., New York, engineer and designer of steel plants, foundries,

G. B. Erickson, who at one time was affiliated with the Duluth Brass Works, with A. A. Williams, formerly of the Duluth Gas Engine Works, Duluth, Minn., have organized the Crescent Brass Foundry Co., Superior, Wis.

J. W. Weinland has resigned as manager of the brake beam department sales of the American Steel Foundries, Chicago. He has been made Chicago district manager of the Liberty Steel Products Co., New York.

Charles B. Bohn, who resigned a few weeks as manager of the Detroit plant of the Aluminum Castings Co., has organized the Charles B. Bohn Foundry Co., Hart avenue, Detroit, to manufacture brass aluminum and bronzé castings.

Paul H. Berggreen has been placed in charge of the St. Louis office in the Railway Exchange building, opened by the Brown Instrument Co., Philadelphia, for the sale of its pyrometers in the southwestern part of the country.

John F. Darrah is now the sole Alabama representative of the Link-Belt Co., Chicago, since E. Francis McCrossin has found it necessary to withdraw from the firm of McCrossin & Darrah because of his engineering work which requires his entire time.

J. R. McWane, president of the American Cast Iron Pipe Co., Birmingham, Ala., has been appointed chief of the operating standardization staff of the Emergency Fleet corporation. His headquarters will be in Philadelphia.

H. G. Spilsbury, metallurgical engineer for the Metal & Thermit Corp., who has had charge of the alloy sales in the Pittsburgh district, recently moved to New York and his headquarters will be in the home office of the corporation in the Equitable building.

A. M. Minnick, formerly sales manager of the Snyder Electric Furnace Co., Chicago, who for the past two years has been sales manager of the electric furnace department of the John A. Crowley Co., Detroit, manufacturer of the Gronwall-Dixon electric melting and refining furnace, has been appointed first lieutenant in the ordnance department.

Officers for the ensuing year were elected at the annual outing of the Pittsburgh Foundrymen's association, held at the Westmoreland country club, June 17, as follows: President, J. Lloyd Uhler, Union Steel Casting Co., vice president; A. M. Fulton, Fort Pitt Malleable Iron Co.; secretary, Bayard Phillips, Phillips & McLaren Co.; and treasurer, William J. Brant, W. J. Brant Co.

Eugene W. Lewis has resigned as vice president and director of the Timken-Detroit Axle Co., Canton, O., to devote his entire time to work for the government. A. R. Demory, vice president, has been elected vice president and general manager; Frederick C. Gilbert, secretary, has been made vice president in charge of sales and advertising, and C. W. Dickerson, treasurer, has been elected secretary and treasurer.

John T. Llewellyn, vice president of the Chicago Malleable Castings Co., has been elected president of the Allied Steel Castings Co., which recently took over the steel castings plants of the Whiting Foundry Equipment Co., West Harvey, Ill. C. J. Nash, president of the Universal Draft Gear Co., has been made vice president; James S. Llewellyn, secretary of the Chicago Malleable Castings Co., secretary and treasurer, and W. H. Tobias, secretary and treasurer of the Union Draft Gear Co., assistant secretary.

Lawrence Fitch, president of the Western Malleables Co., Beaver Dam, Wis., and treasurer of the Globe Seamless Steel Tubes Co., Milwaukee, has been made president of the Independent Harvester Co., Ltd., which is the new name of the recently reorganized Independent Harvester Co., Plano, Ill. Other officers are as follows: Albert J. Earling, chairman of the board, Chicago, Milwaukee & St. Paul railway, vice president; A. W. Wilbrand, secretary, Western Malleables Co., Beaver Dam, secretary, and Grant Fitch, vice president, the National Exchange bank, Milwaukee.

W. P. Pressinger, formerly manager of the compressor and engine departments of the Chicago Pneumatic Tool Co., Chicago, has been made manager of sales. Other changes in the company's organization, include the promotion of W. R. Callan, formerly Franklin, Pa., plant manager, to the position of general manager of plants with headquarters in Chicago; G. A. Rees, general purchasing agent, has been promoted to be manager of purchases and stores; H. D. Megart, formerly with the Bethlehem Steel Co., South Bethlehem, Pa., has been appointed assistant to the president.

Important changes in the organization of the tractor works of the Moline Plow Co., Moline, Ill., have just been announced. T. B. Funk, formerly chief engineer and designer, has been appointed general manager and W. L. Carver has been appointed assistant to Mr. Funk. R. R. Keith, formerly affiliated with the Sheffield Car Co., Three Rivers, Mich., and the Holt Mfg. Co., Peoria, Ill., succeeds E. L. C. Clark as general superintendent. W. McClellan, who has been associated with the company for many years, succeeds Paul Ramp as foundry superintendent. H. Robinson is the purchasing agent. Mr. Ramp has been employed by Deere & Co., Moline, Ill., and is serving in an advisory capacity covering foundry operations.

Master Patternmakers Organize

To promote closer business relations among firms engaged in the production of wood and metal patterns, the Interstate Pattern Manufacturers' association has been organized and has established headquarters at Columbus, O., in charge of T. T. McGuire, secretary. Officers of this organization follow: President, E. F. Ball, Newark Stamping & Foundry Co., Newark, O., and vice president, Max A. Sills, Superior Pattern Works, Cleveland. In addition to the officers the following constitute the board of directors: E. O. Melvin, Melvin Bros., Columbus, O.; A. E. Schuchert, A. E. Schuchert Pattern Works, Cincinnati; Charles D. Smith, Morner & Smith, Dayton, O.; and J. H. Bridge, Maumee Pattern Co., Toledo, O.

Detroit Foundrymen Elect Officers

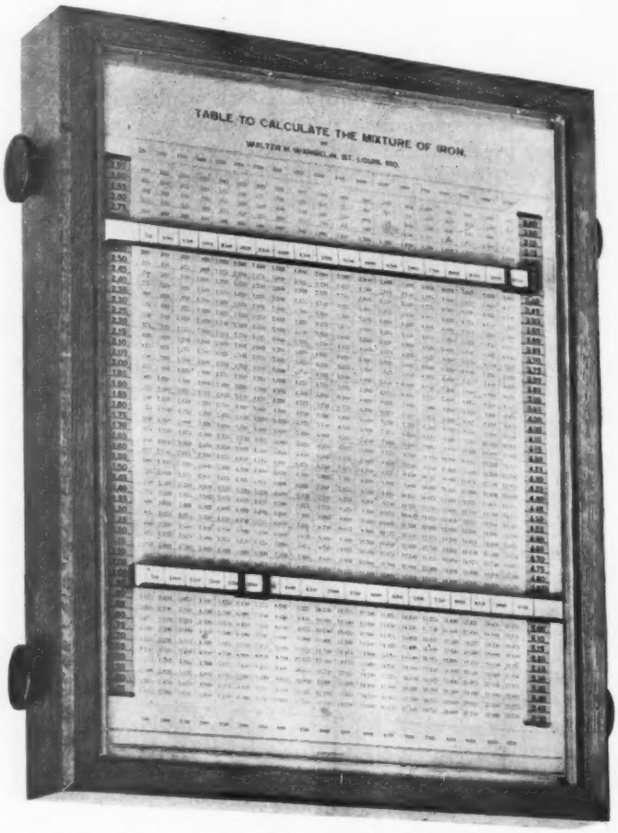
At a recent meeting of the Detroit Foundrymen's association, Detroit, officers for the ensuing year were elected as follows: President, E. I. Chase, Cadillac Motor Car Co.; vice president, B. W. Pike, Detroit Steel Castings Co.; secretary, H. J. Barton, Packard Motor Car Co., and treasurer, J. R. Stewart, General Aluminum & Brass Mfg. Co.

The following were elected to membership on the executive board: A. B. Machon, Aluminum Castings Co.; G. Rousch, Cadillac Motor Car Co.; R. Crawford, Atlas Foundry Co.; F. Erb, Packard Motor Car Co., and F. W. Christian, Acme Foundry Co.

A Machine for Calculating Cupola Mixtures

Details of a Mechanical Calculator Designed to Save Time and Labor in Computing Mixtures by Analysis—Mixing by Fracture Obsolete

PRACTICALLY every foundryman realizes the importance of being able to figure cupola mixtures by analysis rapidly and accurately. It is true that thoroughly skilled experts can determine the composition of iron or steel with considerable precision by examining the fracture, if all of the conditions of manufacture are known. But for the ordinary foundryman this method, which is uncertain at the best, presents special difficulties at the present time when raw materials from widely scattered sources frequently are employed for smelting a single brand of pig iron. Mixing by analysis is the only safe procedure. Fortunately, nothing more than a knowledge of simple arithmetic and the elements of chemistry is required to obtain accurate and satisfactory results. The necessary calculations, however, are somewhat tedious, especially if a large number of mixtures using numerous grades of iron must be figured out monthly. Also when more than two variables appear in the problem, such as sulphur, manganese and silicon, cut-and-try methods must be employed, unless the furnaceman resorts to higher mathematics. For this reason there has grown up a demand for short-cut methods and mechanical devices which will lighten the labor of calculating mixtures for the ordinary foundryman.



MACHINE FOR CALCULATING MIXTURES FOR THE CUPOLA

An effort to meet this demand has been made by W. H. Wangelin, St. Louis, who has prepared a book on mixing furnace charges by analysis and also developed a mechanical calculator designed to cut down the amount of time and effort required to make the necessary computations. Mr. Wangelin's book is in reality a treatise on the mixing of iron written in simple language and his mechanical calculator is an ingenious device worked out in tabular form on the principle of the slide rule. The calculating machine cannot be readily understood without the aid of the explanatory text. The book, however, is self-contained since it includes chapters dealing with the direct computation of mixtures.

In the opening chapter of Mr. Wangelin's book, which contains 284 pages, the nomenclature of iron and steel products is presented and brief definitions of the various kinds of pig iron, steel, wrought iron, washed metal, etc., are presented. The second chapter takes up the metallurgy of iron in a simple manner. The influence of carbon alone and in combination with silicon is described, together with that of sulphur, manganese, phosphorus, etc. The third chapter deals with the effect of the chemical composition and method of manufacture on the appearance of the fracture. In succeeding chapters blast furnace operations, cooling strains in castings, etc., are treated.

In a chapter on buying iron the author points out that the best way is to make use of specifications which set forth the analysis of the iron in a definite manner. Coke also is thoroughly discussed and the author points out that a blast furnace is by no means a large cupola as is often supposed. The peculiarities of the combustion of coke in cupolas are fully explained.

Following these introductory chapters, Mr. Wangelin takes up the calculation of mixtures by analysis and describes the operation of his calculating machine. Methods of calculating mixtures without the use of the machine also are explained and the principles in both cases are illustrated by a large number of actual examples which have been worked out in detail. The Wangelin calculating machine consists of a tabular arrangement of figures which show the excess or shortage of any element, such as silicon, in the several constituents in a given mixture. The proper weight of each constituent, or portion of the charge, necessary to give the correct final chemical composition, may be read directly from the table, the columns being arranged in increments of 50 pounds. The use of the table or calculating machine is based on the following rule or principle: "Where two or more kinds of iron with varying amounts of silicon are used to make up a given mixture, the total of the plus amount in the high-silicon iron must be equal to the total of the minus amount in all of the low-silicon irons in the mixture." This rule is self-evident. The silicon in the high-silicon iron must raise the lower-silicon iron to the figures specified in the mixture in question. If the surplus of silicon in the high-silicon iron is greater than the shortage of silicon in the low-silicon iron, then the mixture will contain too much silicon; on the other hand, if the amount of high-silicon iron is insufficient to balance the shortage of silicon in the low-silicon iron, then there will not be enough silicon in the mixture.

To take care of the varying amounts of silicon, the tabular calculating ma-

chine is equipped with two movable tapes on the left and right margins of the table respectively. These tapes show varying silicon contents in increments of 0.05 per cent. The right hand tape is printed in black to represent all iron higher in silicon than that specified in the mixture to be calculated. The left tape is printed in red to represent all irons lower in silicon than the figures specified. The apparatus also is provided with two movable arms equipped with sliding markers so that the figures in the table may be easily read off. The whole device is enclosed under glass in a substantial polished wood frame.

For calculating the amount of silicon in simple mixtures without the use of the calculating machine, Mr. Wangelin presents the following rule:

Subtract the amount of silicon in the low-silicon iron from the amount of silicon in the mixture and the difference is the number of parts of high-silicon iron to take.

Subtract the amount of silicon in the mixture from the amount in the high iron and the difference is the number of parts of low silicon to take.

Divide the number of parts of high silicon iron contained in the mixture by the number of parts of low silicon iron in that mixture, and you have the number of parts of high silicon iron to one part of low silicon iron to make the mixture in question.

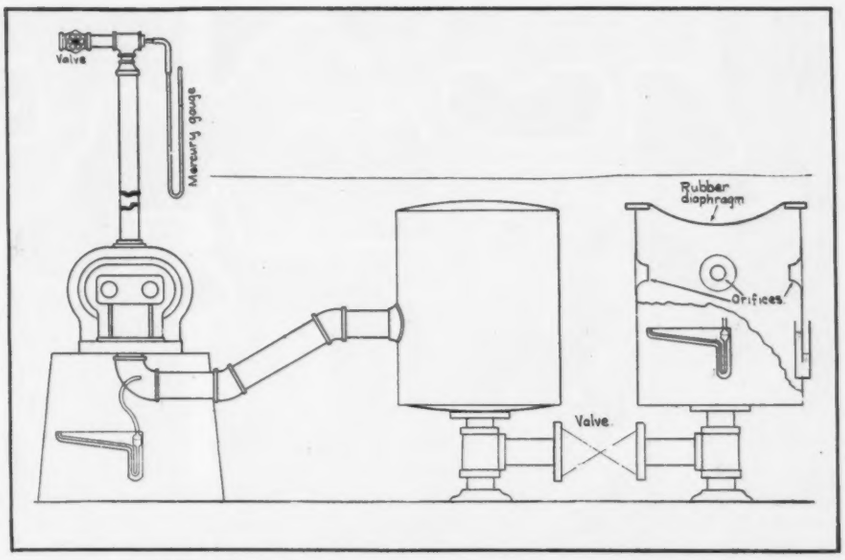
Divide the number of parts of low silicon iron contained in the mixture by the number of parts of high silicon iron in that mixture and you have the number of parts of low silicon iron to one part of high silicon iron.

Divide the number of parts of low silicon iron contained in the mixture and the number of parts of high silicon iron in the same mixture by the sum of these two parts and you have the number of parts of high silicon and the number of parts of low silicon iron to make one part of the mixture.

In a similarly thorough way, Mr. Wangelin has worked out all of the problems relating to the mixing by analysis. His book also explains a method of calculating the amount of finals to be added to the bath in making open-hearth steel, in order to bring the carbon content to the proper figure.

Converting Brass Scrap Into Briquet-Ingots

The Eastern Brass & Ingot Corp., Waterbury, Conn., announces that its equipment for briquet-ingot conversion of cartridge case turnings and similar metal scrap is now complete and in operation. A bulletin has been published by this corporation which describes the service rendered. The business of this company is to convert nonferrous scrap, chips, turnings, etc., into solid ingots and merely to charge a conversion fee. The value of charging into brass furnaces, crucibles, etc., scrap metal in compact form is appreciated by foundrymen generally and these briquets eliminate oxidation almost entirely.



ARRANGEMENT OF APPARATUS FOR TESTING ROTARY BLOWER

Testing Rotary Blowers

Tests to determine the volume of gas delivered by centrifugal exhausters are more easily and more frequently made than the corresponding tests of rotary exhausters of the Roots or Connersville types, because the discharge of the latter is pulsating. Nozzles or orifices cannot be used to measure pulsating flow unless the pulsations are eliminated. These tests are seldom performed on rotary exhausters because every such machine is a meter of the displacement type. The speed of the exhauster is a measure of the quantity of gas delivered. A definite quantity of gas is imprisoned during each cycle and delivered positively, except for the leakage or slip. The latter is constant regardless of speed, depending only upon the inlet and outlet pressures, and upon the density of the gas being exhausted.

In each rotary exhauster there is a speed, commonly referred to as the slip, at which the leakage accounts for all of the gas handled by the exhauster. Above this speed the exhauster delivers its full displacement to the discharge system. The probable delivery, therefore, is found by multiplying the difference between the slip speed and the actual speed by the displacement of the exhauster per revolution. Evidently, the volumetric efficiency increases with the speed. When the speed of the exhauster is 10 times the slip speed, the volumetric efficiency is 90 per cent. Some operators of rotary blowers and exhausters believe that other factors enter into the rate of delivery. The belief is rather general that pressure drop due to friction in the intake pipe reduces the delivery and counteracts the increase in efficiency due to the higher ratio of actual speed to slip speed.

These theories were recently investigated by Professor W. Trinks of the Carnegie Institute of Technology, who made tests on a rotary blower which was built by the P. H. & F. M. Roots Co., Connersville, Ind. The arrangement of the testing apparatus is clearly shown in the accompanying illustration. The air enters the right-hand tank through standard nozzles. This tank is closed at the top by a thin rubber diaphragm, the mass of which is so small that it vibrates with the pulsations of the air in the intake pipe and maintains practically a steady flow of air through the nozzles. When the blower is in operation the oil in the draft gage near the blower vibrates with the pulsations in the air column, while the oil in the draft gage at the measuring tank is motionless. The water seal at the extreme right saves the rather expensive rubber diaphragm in case the blower is started with all the nozzles closed. The intermediate tank between the measuring tank and blower is not absolutely necessary in this test, because the vacuum produced is not greater than the rubber diaphragm will allow.

The San Francisco office of the Blaw-Knox Co., Pittsburgh, has been removed from the Rialto building to the new office and warehouse of this company at 528-530 Second street. O. B. Pulis is in charge as manager.

Fig. 1—Operator Placing Core Box and Core on the Machine.

Fig. 2—Drawing the Core Box From the Core is Accurately Performed by the Apparatus

Universal Sensitive Core Machine to Aid Output

WOMEN are rapidly replacing men in the core rooms of foundries and to aid them in coremaking operations, new equipment is being devised that will ease their labor and at the same time increase production and improve the quality of the output. In the accompanying illustrations is shown a simple core machine, designed and built by the E. J. Woodison Co., Detroit, which draws the box off the core absolutely straight, thereby insuring the accuracy of the contour of the core and reducing spoilage from breakage.

The machine consists of an upright guide made of steel tubing, 4 inches in diameter, in which travels a counterweight attached to the drawing arm, thus making it possible to lift the core box with little effort on part of the operator. The drawing arm is attached to a steel tube, 1¼ inches in diameter, which travels vertically in the machine head or guide arm. The latter is set in ball-bearings on the upright guide. On the base of the machine is a leveling device to compensate for any inequalities in the core plate or box. Adjusting nuts are provided to take up wear. The core box lifting arm is dovetailed and fits into a casting attached to the bottom of the core box, which is provided with a dovetailed slot. The lifting arm is inserted in this slot thereby insuring rigid support for the core box.

In Fig. 1 the coremaker is placing the core, box and plate on the machine. The lifting arm engages the dovetailed, slotted casting on the core box by a forward movement, while the plate rests on the adjustable leveling table. An electric vibrator is attached to the drawing arm and the switch is operated by the foot of the operator. The box is vibrated, the coremaker grips both sides and by an upward movement, draws the box from the core. As previously stated, the drawing of the core box is facilitated by a counterweight in the upright guide arm. In

FIG. 3—INSIDE OF CORE BOX AT THE LEFT AND CORE AT THE RIGHT

FIG. 4—TWO OPERATORS MAY USE ONE MACHINE TO ADVANTAGE

Fig. 2 the operator is lifting the box from the core, shown at the right, Fig. 4. At the left of Fig. 3 the operator is holding the core box, showing the inside. The box is 5 inches high, 14 inches long and 11½ inches wide.

That this machine can be used to advantage by two operators is illustrated in Fig. 4. Here the operations of making the core are so timed that one operator is drawing the core box on the machine while the other is ramming another core. That this machine is adapted for the production of a wide variety of intricate cores is indicated by the illustration above, Figs. 1 and 2.

Keep Your Coke Dry

By Edward H. Schwartz

Notwithstanding the fact that moisture in coke greatly retards melting and absorbs a large number of heat units in its removal, nevertheless many foundrymen still are of the opinion that moisture in the fuel is beneficial in cupola operations. As a matter of fact, the cost of eliminating moisture in coke is unusually high and in view of the fuel scarcity, foundrymen should keep coke under cover to prevent it from absorbing moisture.

It requires approximately 14 pounds of coke to evaporate 1 pound of water, and 2000 pounds of coke easily can contain as much as 2 gallons, or more of water. Two gallons of water weigh 16-2/3 pounds, and it will require 235 pounds of coke to evaporate this amount of water to steam. Therefore, 1 ton of coke containing 2 gallons of water, 10 per cent of ash and approximately 1 per cent of sulphur will leave only 1500 pounds of effective fuel per ton to melt the iron. Therefore the other 500 pounds represent an actual loss.

It has been proved that dry coke melts iron more satisfactorily and it is well known that when there is little moisture in the atmosphere, less fuel is required than otherwise. It is the patriotic duty of every foundryman to keep his coke piles as dry as possible and this only may be effected by keeping this fuel under cover.

The Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has purchased the plant of the Krants Mfg. Co., Brooklyn, N. Y., manufacturer of safety and semisafety electrical and other devices, such as distribution panels, switchboards, floor boxes, etc. The supply department of the Westinghouse company will serve as exclusive sales agent for the products of the Krantz Mfg. Co., whose business will be continued under its present name. H. G. Hoke will represent the supply department at the factory.

Rolling Cylinder Electric Steel Furnace

In the accompanying illustration is shown a 2½-ton rolling cylinder electric furnace, installed by the Greene Process Metal Co., Seattle, in the plant of the Olympic Steel Works, of that city. This furnace is of the arc type and at the side of this unit, at the left, is shown a ¾-ton furnace installed by the Greene company three years ago, which has been in continuous operation since that time. It will be noted that numerous changes in the construction of the furnace have been made and it is claimed that these have greatly facilitated operation. The small furnace, since installation, has averaged about 70 tons of metal per month, with a yield in good castings of from 70 to 72 per cent.

ROLLING CYLINDER ELECTRIC FURNACE OF 2½-TON CAPACITY IN THE FOREGROUND, AND OF ¾-TON CAPACITY AT THE LEFT

The furnace shell of the large unit is sufficiently heavy to withstand the strain due to the expansion of the lining, the latter being accessible through both back and front doors, so that any part may be repaired quickly. The doors are similar in design and operation to those of the open-hearth type and they can be sealed quickly when the furnace is in operation. The furnace rolls on heavy steel rails, thereby eliminating the tilting of the furnace on trunnions. The rolling operation is effected by hydraulic cylinders. The roof of the furnace is arched in one direction only and standard silica brick shapes are employed, special shapes having been eliminated entirely. Several of these furnaces already have been installed and are in operation.

Function of Lead in Bearing Metals

The surface of a bearing should incline gradually toward the shaft from the point of no pressure, where the oil is introduced, toward the point of greatest pressure, where the load is supported. At this point, the thicker the film of oil the better. Above a certain pressure, the oil is squeezed out of a bearing, and then the bearing surfaces in contact are entirely metallic. Under such conditions the qualities of the bearing metal are revealed. When a bearing is subjected to a gradually increased load, there will come a point where the friction increases out of all proportion to the previous gradual increase. The load at this point marks the point of cutting, or the metal is said to grip. The harder the surfaces in contact, provided that the pressure is evenly distributed, the less the friction and the higher the load required to produce gripping.

It is impossible for a metal to possess a low coefficient of friction and durability to a high degree. Lead is the best wearing metal, but owing to its

tendency to adhere to the shaft and to cause excessive friction between its particles, it does not rank high in frictional resistance. For low temperature of running it is well to avoid lead in any quantity. Where low temperature of running is important, and in the case of high speeds where the heat generated is considerable, it is necessary to have a metal with a low specific heat and a high thermal conductivity. In this respect the white metals with a tin base will be found preferable to those high in lead.

Win-the-War Methods at the Essington Foundry

(*Concluded from page* 301.)

mer, two large and two small heating furnaces, two annealing furnaces, hand forges, case-hardening equipment, bolt heating machines, and tool dressing appliances, as shown in Fig. 17. The heating and annealing furnaces are served by hot-blast gas producers.

All of the buildings composing the plant are steam-heated and are provided with modern facilities for the comfort of the workers. The entire plant is served by standard gage tracks. The intra-plant railroad system is equipped with electric locomotives and cars; this road, when completed, will comprise about 41 miles of track.

The program for future expansion when carried out will result ultimately in making the Essington plant at least three or four times larger than it is at present.

Applying the Principles of Cost Engineering

(*Concluded from page* 309)

Administration and selling expenses include executive salaries, clerks' salaries, superintendent's salary, advertising, advertising and commercial postage, stationery, office supplies, telephones, telegraph, bad accounts and collection expenses, discounts and deductions to customers, interest and insurance on work in process, interest on accounts receivable and cash for requirements of business, salesmen's salaries and commissions, executive and selling traveling expenses, samples and designs, federal and corporation taxes, donations, organization dues, etc.

I hold the following principles to be fundamental:

The cost of a manufactured article is the sum of the expenses involved in its production and distribution up to the moment at which cost is determined.

Every cost element or expense item is definite in amount and purpose, and anticipates a beneficial equivalent in service or commodity.

In the distribution or charging of expenses, consideration should be given to the benefits derived, so that the charges may be justly assessed where the benefit is conferred and in true proportion to the measure of benefit.

Each of the items of expense listed in Mr. Bird's paper bears no relation to wages. Thus the benefit conferred by the expenditure does not increase or decrease with fluctuation in wages, or as between the product of men receiving different rates of wages. Neither is there a relation between the wages paid and the total of these items applicable to the product of the workmen.

In cost engineering each process is considered separately and each item of expense individually applied by measurement so that expense and benefit are in proportion, making it impossible for one process to carry any of the expense belonging to another.

How Titanium Affects Softer Metals

When titanium, in the metallic form, is added to molten zinc, tin or lead, only a minute amount of the more refractory metal is dissolved and incorporated by the metals of lower melting points. For instance, when zinc is heated to the point at which it strongly volatilizes, and if powdered titanium is added, it will ignite on the surface of the zinc and burn to the dioxide. However, large pieces of titanium do not burn, nor will they dissolve more than superficially. The small amount of titanium that is dissolved by zinc, tin and lead, when strongly heated, produces distinctive colors when the metal is poured into ingots. In the case of zinc these colors are liable to be a light blue at the pouring end and a purple bronze at the extreme end of the cast. The colors of zinc with traces of titanium are inclined to blue; those of tin, dark bronze while those of lead run to purple, green and gold.

Interesting Examples of Practical Patternmaking

(*Concluded from page* 330)

planed to the desired angle and the holes bored and reamed. The piece is then cut apart, and the ends of the pieces sanded, completing the patterns.

The first step in making patterns for washers having angles of 30 and 45 degrees respectively is shown at *B*. The angles on the two pieces forming each strip have been planed carefully and the pieces fastened together with nails within the circles outlining the patterns. In the illustration, however, the pieces have been pulled apart slightly to illustrate the method more clearly. Holes have also been bored in the center of each outline for lathe chucking. The pieces are next sawed out on the band saw in the circular form shown at *C*. The next operation is to mount them in the lathe where the outside is turned and finished to the desired diameter. They are chucked next by the outside diameter and the center holes bored and finished. Two larger washer patterns are shown at D.

In making washer patterns by the method outlined, time was saved in cutting the angle on the long pieces, for one long angle can be planed in the same time that would be required to finish an angle on a single pattern, if this was done after the pattern had been turned to shape.

Catalog Sizes Standardized

Recently a national catalog conference was held at Chicago for the purpose of considering the standardization of trade catalogs. This conference was attended by delegates from 23 associations representing various industries of the United States, the department of commerce and the Chamber of Commerce of the United States, as well as a large number of detached representatives of various trades. It was decided to urge that all catalogs intended for purchasing agents be 7½ x 10⅝ inches. Pamphlets and booklets made in half the standard size will meet with the approval of the purchasing agents provided they are saddle-stitched so that when opened they will measure 7½ x 10⅝ inches for convenience in filing. Booklets, 5 5/16 x 7½ or 3¾ x 10⅝ inches will be acceptable.

How to Alloy Phosphor Bronze

The manufacture of phosphor bronze is discussed by Prof. W. W. Rogers of the Stamford Rolling Mills Co., in a pamphlet recently issued by that company. Prof. Rogers claims that the phosphor bronze that has the best all-around properties for rolling and drawing into wire has the following approximate composition:

	Per cent
Copper	95
Tin	5
Phosphorus	0.05 to 0.15

This alloy, when annealed, has a tensile strength of about 47,000 pounds per square inch and an elongation of about 70 per cent. When rolled or drawn to spring temper, it will develop 120,000 pounds per square inch, with an elongation of only 2 per cent or less. Fine wire will develop 160,000 pounds tensile strength and over. At maximum spring temper the ultimate breaking strain and the

elastic limit are almost identical, with practically no elongation.

In its manufacture the first step is to prepare the phosphor copper. This is accomplished by heating copper ingots in a graphite crucible to almost their melting point, but not allowing the copper to flow. When this temperature is attained, yellow stick phosphorus is thrown in, which at once combines with a portion of the copper with a sufficient rise in temperature to melt it. The addition of phosphorus is continued until the charge has melted. It is then poured into shallow slab molds, and, when cold, may be easily broken. This process yields a phosphor copper containing from 4½ to 5 per cent phosphorus.

The next stage is to alloy this phosphor copper with tin in the following proportions:

	Per cent
Phosphor copper	51½
Tin	48½

The phosphor copper is first melted in a graphite crucible, the tin added, heated until thoroughly fused, well stirred and poured into shallow slab molds. To complete the process, it is only necessary to mix the copper with the phosphor-copper-tin alloy. A 100-pound charge would consist of 90 pounds of high grade copper and 10 pounds of the phosphor-copper-tin alloy. To do this, melt the copper under charcoal, add the phosphor-copper-tin alloy, raise the temperature to the required pouring temperature, mix thoroughly and pour into molds of convenient size and shape.

Great care must be exercised in handling the phosphorus used in the making of the phosphor-copper. The contents of the tins in which the phosphorus is sold should be emptied into a bucket containing water, and the sticks of phosphorus completely submerged. The hands should be protected with asbestos gloves.

WHAT THE FOUNDRIES ARE DOING

Activities of the Iron, Steel and Brass Shops

The Consolidated Press Co., Hastings, Mich., is planning the erection of a foundry.

Charles Bohn, Chene and Finley avenues, Detroit, is planning the erection of an aluminum foundry, 70 x 140 feet.

The Buhl Malleable Co., Detroit, is making extensions to its foundry which will cost approximately $35,000.

The contract for an $18,000 foundry has been awarded Joseph Christenson, Orange, N. J., by C. A. Goldschmidt.

John A. Worrell, 905 Eighth street, Chester, Pa., has completed arrangements to build a foundry.

Plans are being prepared for a foundry to be built by the Demarest Heating Corp., Buffalo.

The Acme Steel & Malleable Co., Buffalo, is contemplating the erection of a brick and steel foundry building at a cost of $25,000.

The H. & H. Foundry, Stamford, Conn., is planning the erection of another building which will be used as a steel foundry.

The American Foundry Co., Seattle, has obtained a site and will build a foundry of 20 tons daily capacity.

The Hill Pump Co., Anderson, Ind., is erecting a foundry, 100 x 200 feet, at a cost of $45,000.

The Standard Crucible Steel Co., Milwaukee, contemplates the erection of a foundry, 123 x 422 feet.

The Essex Foundry Co., Newark, N. J., has had plans prepared for the erection of a 1-story brick addition, 41 x 75 feet.

Henry E. Mueller, St. Louis, care of Kresse & Ernst, Victoria building, plans the erection of a 2-story foundry.

The Cutler-Hammer Mfg. Co., Milwaukee, contemplates the erection of a foundry, 40 x 50 feet, to cost $6000.

The Norfolk Foundry & Machine Co., Hartford, Conn., has been incorporated with a capital of $125,000 to manufacture castings.

The General Motors Co. is having plans prepared for a gray iron foundry to be erected at Saginaw, Mich.

Improvements to the Egyptian Iron Works plant, Murphysboro, Ill., will include the replacing of the old foundry with an entirely new shop. A tool and storage room also will be built.

The Aldrich Pump Co., Allentown, Pa., will receive bids shortly for the erection of a $6000 addition to its foundry.

The general contract for a 2-story, 40 x 70 foot foundry, has been awarded by the Bullard Machine Tool Co. to John R. Sheehan.

The Auto Power & Mfg. Co., Omaha, Nebr., is planning to build a foundry, 80 x 240 feet. Stockham & Baker, Railway Exchange building, have the contract.

The Empire Brass Foundry, Richmond, Ind., recently was capitalized at $10,000 and has been organized to manufacture brass and bronze castings.

The John B. Morris Foundry Co., Cincinnati, has applied for permits to construct two additions to its foundry at a cost of $6600.

The United States Auto Gear Shift Co., Eau Claire, Wis., has awarded the contract for the erection of a foundry and other improvements.

The Production Pattern & Equipment Co., Milwaukee, recently incorporated with a capital of $25,000, will manufacture patterns and foundry equipment.

The David Bradley Mfg. Co., Bradley, Ill., contemplates the erection of a malleable foundry as an addition to its plant. J. C. Bohner is the manager of the company.

The Enterprise Foundry Co., Superior, Wis., has been organized by S. A. Riches and associates and is erecting a gray iron and malleable works.

The National Steel Foundries, Milwaukee, will start construction shortly on an addition, 80 x 140 feet. Richard P. Tell is president and general manager.

The Trenton Malleable Iron Co., Trenton, N. J., will start work shortly on the construction of a $10,000 foundry addition, 44 x 117 feet.

The Industrial Foundry Co., Pottsville, Pa., has broken ground for a foundry, 90 x 120 feet, which will be erected at a cost of $30,000.

The Reliance Mfg. Co., Pasadena, Cal., capitalized at $50,000, has been organized to operate a foundry, by John A. Powell, Wilbert Morgrage and W. M. Thompson, of Pasadena.

The Auto Power & Malleable Mfg. Co., First National Bank building, Plattsmouth, Nebr., will build a brass foundry, 80 x 240 feet at a cost of $150,000.

The Wilson Foundry & Machine Co., Pontiac, Mich., C. B. Wilson, general manager, is planning to build a foundry addition, 41 x 169 feet.

Fairbanks-Morse & Co., Beloit, Wis., C. H. Morse Jr., president, 900 South Wabash avenue, Chicago, contemplates the erection of a foundry at an approximated cost of $300,000.

The Lenni Steel Co., Lenni, Pa., contemplates the erection of a foundry. C. W. Jenkins, 130 South Fifteenth street, Philadelphia, will be in charge of the construction.

The National Roll & Foundry Co., Avonmore, Pa., is building an 80-foot addition to its foundry and is installing its third air furnace.

The Monarch Tractor Co., Watertown, Wis., is making additions to its machine shop and assembling room and is contemplating the erection of an addition to its foundry. F. L. Thomas is secretary and treasurer.

The Universal Machinery Co., West Allis, Wis., is awarding contracts for the erection of a foundry and core room to cost $50,000. The foundry will be 90 x 160 feet; the core room 60 x 66 feet.

The Crucible Steel Castings Co., Milwaukee, has awarded contracts for the erection of a foundry addition to its plant at 612 Clinton street. The extensions will cost approximately $10,000.

The Hays Foundry & Iron Works, Newark, N. J., have completed plans for the erection of an addition, 50 x 250 feet. The construction work will be done by the American Concrete Steel Co.

The Chuse Engine & Mfg. Co., Mattoon, Ill., recently increased its capital and has bought a site adjoining its plant on which it will erect a foundry and machine shop. H. A. Chuse is the general manager of the company.

The Electric Steel Co., Chicago, has a foundry building under construction, 130 x 300 feet, a materials yard with a craneway, 48 x 360 feet and a reclamation mixing and

distributing system for handling molding sand. Frank D. Chase is in charge of the work.

The Interstate Foundry Co., Annis.on, Ala., has filed articles of incorporation and has placed its capital at $75,000. The company will engage in the jobbing foundry business. Frank Leigh, J. A. Hardin and G. G. Britton are the incorporators.

Architect Frank E. Gray, Milwaukee, has awarded contracts for the erection of a foundry, cupola and core room building, for the Universal Machinery Co., Milwaukee. The building will be 2-story, 90 x 160 feet. It will cost approximately $65,000. The steel work has been let to the Lakeside Bridge & Steel Co., North Milwaukee.

The Fahnestock Mfg. Co., Avonmore, Pa., is adding a 60-foot extension to its steel foundry, which greatly will increase the output. Among the equipment that is being installed is a 10-ton cleaning room crane and a 15-ton ladle crane with a 5-ton auxiliary hoist. The cleaning room crane will serve a new annealing furnace that now is being built.

A change in the ownership of the American Range & Foundry Co., Cleveland, recently has taken place and the firm name has been changed to the Vahan Foundry Co. Officers of the new organization follow: President, Frank S. Shields, president Cleveland Milling Machine Co.; vice president, R. B. McHenry, formerly affiliated with the Johnston & Jennings Co. and Joseph Dyson & Son and secretary-treasurer, L. M. Lucius. A specialty will be made of light and medium gray iron castings.

The National Stove Repair Co., Miamisburg, O., recently organized, has acquired the plant of the Hoover & Gamble Foundry Co. and is specializing in stove and range repair parts. The stove and range repair department of the John B. Morris Co., Cincinnati, has been purchased by the National company which will continue to make this line of work. In addition to the large foundry, the plant at Miamisburg has a warehouse containing 50,000 square feet of floor space in which an extensive line of castings and patterns will be carried in stock.

The National Brass Works, Inc., Los Angeles, Cal., recently organized with a capital stock of $50,000,000 has the following officers: President, H. L. Hartman; vice president, W. W. Witherby; and secretary and treasurer, Leonard Ruegg. Messrs. Hartman and Witherby were the former owners of the National Brass Works and Mr. Ruegg recently acquired an interest. The plant will be extended by the erection of additions costing $10,000 that will provide additional floor space of 15,000 square feet. The recent expenditures for new machinery approximate $10,000. The company specializes in brass, bronze, zinc, bell metal, aluminum and gun metal castings. Finishing and plating departments also are operated.

NEW TRADE PUBLICATIONS

FORGES.—The extensive line of portable forges manufactured by the Buffalo Forge Co., Buffalo, is illustrated and described in a 112-page catalog recently issued by this company. Practically every conceivable type of forge is shown.

IRON CEMENT.—Instruction book No. 16, published by the Smooth-On Mfg. Co., Jersey City, N. J., contains 144 pages and discusses comprehensively the application of iron cement for various purposes. Its use for repairing defects in castings in iron foundries, is well known by the trade. This product also has a wide variety of other uses.

OXYGEN AND HYDROGEN GENERATOR. — The Levin oxygen and hydrogen generator is illustrated and described in a circular recently issued by Electrolabs, 15 William street, New York. This generator is of the unit type and consists of three parts. The oxygen is generated in the two outer and the hydrogen in the center compartment. One of these generators will produce 38.4 cubic feet of oxygen and 76.8 cubic feet of hydrogen in 24 hours.

LIFT TRUCKS.—A handsomely-illustrated and well-arranged 32-page catalog devoted to lift trucks has been issued by the Stuebing Truck Co., Cincinnati. The wide application of these lift trucks is shown pictorially. The handling of core racks in foundries is illustrated, these racks being conveyed from the core rooms to the ovens by these trucks and by the employment of only one operator. Other illustrations show the handling of steel in the plant of the Standard Parts Co., Cleveland; foundry supplies in the plant of the Cleveland Osborn Mfg. Co., Cleveland; machine tools in the plant of the Cincinnati Shaper Co., Cincinnati; automobile castings in the plant of the Continental Motors Corp., Detroit, etc. Common types of platforms and racks also are illustrated which are adapted to almost all industrial purposes.

PNEUMATIC TOOLS AND OTHER EQUIPMENT.—The Ingersoll-Rand Co., 11 Broadway, New York, recently has issued considerable printed matter covering its various lines of machinery and equipment. An 8-page booklet is devoted to a shank and bit punch for punching out holes in bits and shanks of hollow drill steel. A 4-page folder describes briefly its line of pneumatic tools, gives tables of sizes and capacities and also contains illustrations showing all tools and their applications. Other pamphlets are devoted to caulking machines, evaporator tube cleaning and other labor saving pneumatic tools, barometric condensing plants, steam engines, portable mine car air compressors, etc.

ACETYLENE APPARATUS.—A comprehensive 48-page catalog devoted exclusively to an extensive line of acetylene apparatus, has been issued by the Alexander Milburn Co., Baltimore. The products manufactured include portable carbide lights, headlights, marine beacon lights, oxy-acetylene welding and cutting apparatus, etc. The lights manufactured by this company are used extensively for artificial illumination by industrial plants, in mines, by ship yards, etc. These lights are made in sizes from 100 to 15,000 candlepower. The operation of these lights involves the use only of commercial carbide and water. Complete oxy-acetylene plants for cutting and welding also are described and illustrated and numerous views are included, showing the application of this welding apparatus.

SAND BLAST MACHINERY.—A 40-page catalog devoted to sand blast machinery and foundry equipment, has been issued by the J. W. Paxson Co., Philadelphia. The sand blast machines illustrated are for high or low pressure operation and are equipped with water traps. Operating directions are included, which contain many valuable suggestions for the users of sand blast equipment. Standard sizes of machines and capacity, with their air and power requirements also are given. Sand blast accessories are illustrated and described, including helmets, hose, nozzles and nozzle holders, eye protectors, steel grip gloves, respirators, sand and dust boxes, elevators, revolving screens, portable screens, etc. Tilting sand blast tumbling barrels of various types also are shown and drawings of various installations are included. The catalog also contains views of several installations in different foundries. Air compressors also are described as well as sand driers and a page is devoted to sand blast sand that is furnished by this company.

HIGH CONDUCTIVITY COPPER CASTINGS.—A 16-page booklet issued by the Titanium Bronze Co., Niagara Falls, N. Y., is devoted to its line of high conductivity copper castings. It is well-known that small quantities of impurities in copper castings greatly reduce their conductivity, but the castngs made by this company contain 0.03 per cent or less of impurities, guaranteeing a minimum electrical conductivity of 75 per cent and run as high as 93 per cent, depending largely upon the design. It frequently is assumed that castings containing 98 per cent of copper will have a similar conductivity, but this does not follow since the remaining 2 per cent of other ingredients actually may reduce the electrical conductivity as low as 40 per cent. The Titanium Bronze Co. produces castings containing as high as 99.8 per cent copper with a consequent high electrical conductivity. Extensive research with special deoxidizers enables the Titanium company to produce almost pure copper castngs averaging 89 per cent electrical conductivity. If hardness and maximum conductivity are desired this can be obtained in simple shaped castings by forging. A special process also has been devised for producing density in massive castings.

ROTARY GAS EXHAUSTERS. — In a well-illustrated, 40 page catalog, gas exhausters built by the P. H. & F. M. Roots Co., Connersville, Ind., are illustrated and described in detail. The gas exhausters and boosters built by this company are employed extensively for pumping gas. Briefly described, an exhauster has a suction or inlet pressure slightly less than atmospheric pressure, while the suction of a booster is greater than atmospheric. At present there are four distinct fields of application for these gas pumps, including the installation of foul gas exhausters in illuminating gas works to handle the gas as it comes from the retorts. Gas boosters take a clean gas from the holder and compress it to a pressure ranging up to 10 pounds per square inch for the purpose of distributing it into the city mains. Gas exhausters for by-product coke ovens are foul gas exhausters on a large scale, with the added difference that both suction and discharge pressure differences are considerably greater than in municipal gas plants. The fourth field is that of handling non-corrosive gases for any pressure difference up to 10 pounds per square inch. The operating principle of this machine is described in detail. Various types are illustrated by halftones and line drawings. Tables of sizes and capacities are included and rotary blast gates and flexible couplings also are described. Charts are given relating to the proportioning of gas pipes, etc.